Dr Baly –
with the Authors
best respects

ON

THE CORPUSCLES

OF

THE BLOOD.

BY

MARTIN BARRY, M.D., F.R.S., F.R.S.E., &c.

From the PHILOSOPHICAL TRANSACTIONS.—PART II. FOR 1840.

LONDON:
PRINTED BY R. AND J. E. TAYLOR, RED LION COURT, FLEET STREET.
1840.

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XXIV. *On the Corpuscles of the Blood. By* Martin Barry, *M.D., F.R.S., F.R.S.E., &c.*

Received May 14,—Read June 4, 1840.

The principal facts recorded in the following memoir were incidentally observed during the researches which formed the subject of my last communication[†].

(The measurements in this paper, as in former ones, are stated in fractions of a Paris line, and thus expressed (‴)).

Progressive Division of the Blood-disc into Globules.

1. My examinations of the internal generative organs in the Rabbit have generally been made at a period when these parts were found more or less highly vascular. In fluid collected at this period from the surface of the ovary, from the fimbriated portion of the Fallopian tube, or from the infundibulum, it is usual to find a large quantity of corpuscles of the blood, which are present also in other parts of the oviduct. It thus appears that blood-corpuscles become extravasated in these parts at the period in question.

2. Many of these corpuscles present an appearance (Plate XXIX. figs. 1. 2. α) resembling that generally exhibited by the corpuscles in blood obtained by venesection. But a very large number are in altered states, an idea of which may be obtained from such of the objects in fig. 2. as are not distinguished by a letter.

3. More particularly examined, and in considerable number, the objects in question are found to present every shade of transition between the unaltered blood-corpuscle Plate XXIX. fig. 1. α, and the mass of distinct globules, fig. 2. δ. This will be seen on inspecting successively α, β, γ, of fig. 1, and then the numerous unmarked objects in fig. 2; beginning in the latter figure with those most resembling γ of fig. 1[‡].

4. Several of the appearances in the figures just referred to, will be recognized by those who have watched blood-corpuscles in the microscope, when undergoing the first alterations in their form. I find, however, that the presence of blood-corpuscles in these altered states, in the fluid above mentioned, is constant,—and this too when the parts are examined as early as a few minutes after the animal has been killed,—when therefore they are still warm. And what is more, in a portion of the fimbriated

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[†] Researches in Embryology, Third Series: A Contribution to the Physiology of Cells. Philosophical Transactions, Part II., 1840, p. 529, that is, the present volume.

[‡] It is perhaps deserving of notice, that a central pellucid cavity similar to that in other objects of this figure, was not observed in the centre of the mass of globules δ. Does it disappear as these globules form?

extremity of the Fallopian tube, removed immediately after death, I have seen blood-corpuscles in some of the altered states still circulating, or at least not quite at rest, within a blood-vessel. Hence it seems probable that the changes in question take place within the living body.

5. The altered blood-corpuscles just referred to, at first retain their flattened form, as will be seen on reference to fig. 2, which exhibits a few of them on their edges, or nearly so.—It may here be stated that my observations corroborate those of previous observers, that the blood-corpuscles in the Mammalia are biconcave; yet with Hodgkin and Lister[†], I find them in Man to be rounded at the edges[‡], and not cut off abruptly as they have been described[§].

6. If the elliptic discs surrounding the germinal vesicle in a number of the figures of my "Third Series" be examined, they will be found in many respects to resemble the corpuscle of the blood, which—it will be recollected—in some of the Vertebrata has an elliptic form[‖]. Now all the cells referred to in that Series, were described as presenting in an incipient state essentially the same appearance as the objects surrounding the germinal vesicle. They were shown to exhibit a pellucid space surrounded by a finely granular substance.

7. I am reminded of this state by the appearance of the unaltered blood-disc. And certainly the division into globules to which we have now traced the blood-disc, is very far from lessening the resemblance.

8. A reference is here necessary to my "Third Series" on Embryology, *l. c.*, Plate XXIV. fig. 192. The object there seen consisted of a central pellucid space surrounded by one layer of what later stages showed to have been the foundations of cells. And if that object be compared with some of the altered blood-corpuscles in Plate XXIX. fig. 2. of the present paper, the appearance will be found to be essentially the same in both. Whether the globules into which the blood-disc resolves itself, are the foundations of new corpuscles of the blood, I do not know; but it is certainly not unimportant that there exists so perfect a resemblance, in appearance, between two objects, the nature of one of which has been ascertained[¶].

[†] Translation of Dr. Edwards on the influence of physical agents on Life, Appendix, p. 431.

[‡] I am indebted to the kindness of Professor Rudolph Wagner for some plates, intended to accompany the second part of his "Lehrbuch der Physiologie;" one of which, Tab. XIII., I observe contains figures of mammiferous blood-discs, rounded at the edges; as does also his work, "Beiträge zur vergleichenden Physiologie. Heft II. 1838."

[§] Müller's Physiology, translated by Dr. Baly, Part I., 1837. p. 99. fig. 1.

[‖] The blood-corpuscles of some of the Amphibia present a curious resemblance to many of the elliptic discs figured in my "Third Series" on Embryology, in the present volume.

[¶] The condition of the blood-corpuscles above described (Plate XXIX. figs. 1 and 2.) is obviously that which was particularly observed, not only in very different mammals but also in one of the Amphibia, by Professor Owen (Med. Gaz. Nov. 13, 1839.). This eminent anatomist and physiologist has shown that the appearance in question presents itself in blood so recently drawn, that it cannot be considered as the effect of manipulation. It suggested to him "the idea that the blood-disc was undergoing a spontaneous sub-division into smaller vesicles; and although," he proceeds, "my observations are not at present sufficiently numerous to warrant the

9. The appearance of the globules in question suggests the idea that they may be identical with the so-called "lymph-granules," or blood-corpuscles of the "second form†."

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hypothesis that the development of smaller vesicles within itself is a normal property of the ordinary coloured vesicle or blood-disc, yet the obscurity which still hangs over the origin and reproduction of the blood-discs, and the unexpected constancy of the granulated form in a greater or less proportion of them, while recent, and floating in the serum, in the different species examined, makes me unwilling to suppress an idea, naturally arising out of such observations, and likely to be suggestive of examination of the same appearance by other microscopical observers." At the time of recording the above observations, I was not aware that such an idea had been published. I shall be glad if those observations are such as to confirm it. There is one fact mentioned by Owen which I think particularly deserving of attention here. In describing the blood of a cold-blooded animal—the *Monitor*—he remarks, "many of the discs had the marginal contour slightly crenate, *with lines converging* to the nucleus."—The appearance of the blood-disc when undergoing the changes which we have seen to terminate in a separation into globules, seems to have been noticed by several observers; among whom may be mentioned Hewson and Falconar, and more recently Hodgkin and Lister. It is not easy, indeed, to understand how the sharp-sighted Leeuwenhoek should have suspected the "globules" of the blood to be made of six lesser globules, unless he had seen some of the appearances in question. Some late remarks by Gulliver, to whom we are indebted for a vast number of observations on the size of the blood-discs in different animals, show that this gentleman had long been in the habit of observing these appearances, and that he deemed them of importance, He mentions having observed the "granulated particles in great numbers, both in their serum and in a dry state***in blood examined immediately after it was obtained from the veins of various animals, particularly young kittens. The nature of these particles," he continues, "is worthy of further and special inquiry. They are to be found plentifully during digestion; but, in their deep red colour and chemical properties, they differ remarkably from the granules observed in the chyle" (Lond. and Edinb. Phil. Mag. Jan. 1840.). The same author subsequently remarks, "The granulated particles are almost uniformly smaller than the common discs, and it is not improbable that some of the former may be produced by the irregular shrinking of the latter. In some instances I could not detect any of the granulated corpuscles in the blood immediately after it was taken from the animal, although they were to be seen abundantly after a few hours exposure in the serum to the atmosphere, the temperature ranging between 45° and 50°. In one observation some of the extremely minute spherules which are not uncommon in the blood, were observed to attach themselves to a few of the smaller discs, so as to produce the granulated appearance" (Lond. and Edinb. Phil. Mag. Feb. 1840, p. 107.). It would thus seem, however, that the idea of a division of the blood-disc had not occurred to the author now quoted.

† On the subject of these "lymph-granules" or corpuscles of the "second form," many valuable observations have been communicated by R. Wagner, from whose work—Beiträge zur vergleichenden Physiologie, Heft II. 1838,—I make the following extracts, in which will be found remarks that appear to me to be favorable to the suggestion above offered, on the possible identity of the globules into which the blood-corpuscle divides, with corpuscles of the "second form."

"In the blood of Birds, Amphibia, and Fishes, there is present in greater or less quantity a second form of corpuscles, which at first sight may be distinguished from the real blood-corpuscles, and to which the attention of physiologists was recently directed by Johann Müller. (Burdach's Physiologie, iv. S. 108.) [As Dr. Baly very properly remarks, Hewson probably saw the same objects, considering them the nuclei of the blood-discs. (Experimental Inquiries, &c. Part III. p. 133.) Hodgkin and Lister appear also to have seen them, (*l. c.*, p. 437.)] They have since been seen and closely investigated by many observers, and I long ago considered them at length. (Hecker's Literärische Annalen, 1834, Februarheft.) On the universal presence, the relative quantity, and the size of these granules, we have not yet any complete investigations.***In the arterial blood of a

10. The objects ε in Plate XXIX. fig. 2. were of a reddish colour, but larger than blood-corpuscles. They also presented distinctly a membrane at the surface, and contained globules or discs (each of which had its pellucid centre) surrounding a common pellucid space. One of the objects ε was elliptical, the others appeared more or less globular in form.

11. It is still a question with some, whether the blood-corpuscles in the embryo are formed out of granules of the yelk. My Second Series on Embryology† will I think have served to decide this question; for it was there shown that in the mammiferous ovum there exist no yelk-granules which can be so transformed; the ovum being filled with colourless transparent fluid.

Rapid and incessant Changes in the Form of altered Blood-corpuscles.

12. In Plate XXIX. figs. 3, 4, 5, are seen the momentary forms of objects which I observed in fluid collected on the fimbriated portion of the Fallopian tube, at the periods respectively of 5, 13, and $5\frac{1}{2}$ hours *post coitum.* These objects were altered corpuscles of the blood. Fig. 3. presents a gradual transition from the blood-corpuscles in fig. 1, to objects which in the absence of such connecting links would scarcely have been recognized as such.

13. These altered blood-corpuscles (figs. 3, 4, 5.) were in motion; rarely exhibiting a change of place, but presenting a rapid and incessant change of form. I have had many opportunities for observing these motions, which are often such as to be comparable to the writhings of an animal in pain. Sometimes one of the objects in question assumes in a twinkling an hour-glass shape, as if about to separate into two portions; but as quickly regains its previous form, or assumes a new figure. The condition, however, is by no means one of alternate rest and motion. The motion, as already said, is incessant, and so rapid that it is extremely difficult to catch and deli-

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young man of nineteen years, from whom blood was taken in Bronchitis, I found, besides the regular concave blood-corpuscles (averaging in diameter $\frac{1}{300}'''$), distinctly spherical finely granulated globules of $\frac{1}{500}'''$ to $\frac{1}{600}'''$, in appearance entirely corresponding to the second form of corpuscles, which are so easily demonstrable for instance in the blood of Frogs. Quite similar globules, though in more sparing quantity, I found in my own blood after venesection in consequence of inflammation.***I have since always found these corpuscles in drawn blood. ***They appear to stand in exact relation to the size of the blood-corpuscles of the animal.***They, however, vary much more in size than the [true] blood-corpuscles.***With respect to the form,***I hold them indeed to be globular, but perhaps globules pressed somewhat flat.***They are distinguishable from the other blood-corpuscles, also: 1. by being colourless; 2. by a certain lustre, and the property of strongly refracting light; 3. by their peculiarly granular appearance, so that they might be taken for aggregates of globules (nevertheless it appears to me that they are granular only at the surface)." R. Wagner then shows that the number of these corpuscles of the "second form" is greater in animals well-fed, and he mentions an instance in which they greatly increased after the blood had stood for two hours. R. Wagner, Beiträge zur vergl. Phys. II. pp. 19—48.

† Philosophical Transactions, 1839, Part II. p. 307.

neate any of the forms which arise. Sometimes the corpuscles suddenly become inverted; and I have observed certain of them (fig. 3. β.) which seemed to be horizontally revolving. The field of view in some instances is covered with these moving particles.

14. I have seen these motions of the altered blood-discs when the latter were covered,—in some instances with glass, in others with mica,—and also when uncovered; and I have observed them as late as two hours and a half after death, as in fig. 3[†]. They soon cease after removal of the fluid to the microscope. The cessation is, however, very gradual; rapid change of form passing into gentle undulations; and these being succeeded by an alternation of rest and motion.

15. In fig. 4. I have delineated the forms retained in one instance by four of the corpuscles in question after their motions had entirely ceased. The pellucid centres, such as those seen in the objects of this figure, are often not distinctly visible while the motions are proceeding. Sometimes, however, during rapid motion, I have observed appearances like those in fig. 5; the contained pellucid fluid being now central (α), then on one side (β), or divided into several parts (γ).

16. The addition of cold water does not immediately arrest the motions. I could not discern any in the remains of the corpuscles after dilute acetic acid had been added.

17. I have seen these motions of the altered blood-corpuscles, in fluid collected on the fimbriated portion of the Fallopian tube, in a Rabbit which had not had connexion with the male, but was killed during the rut.

18. They seem to be attended in some instances with a considerable increase in the size of the corpuscle (fig. 3. γ.)[‡].

19. Should these facts be thought to confirm the opinion of Hunter, that the Blood "has life within itself," or "acquires it in the act of forming organic bodies," because its corpuscles in certain altered states exhibit "vital action," still his assertion that "the red globules" are the least important part of the blood, will appear to have no just foundation[§].

[†] The examinations were usually commenced a few minutes after the animal had been killed.

[‡] Reference is made by R. Wagner to a statement of Czermac with which I am unacquainted. "Vital motions," says Wagner, "such as those which Czermac maintains that he has observed (for instance in Blood from the gills of the Proteus), I have never seen; and this assertion certainly rests on an illusion occasioned by the phenomenon which is produced by ciliary motion." Wagner supposes the motions seen by Czermac to have been caused by portions of the gills, the cilia of which set the escaped corpuscles of the Blood in motion (Beiträge zur vergl. Phys. Heft II. pp. 17, 18.).

[§] As stated in the London and Edinburgh Philosophical Magazine for August, 1840, p. 157, my later observations induce me to believe that the rapid and incessant changes in form of altered blood-corpuscles, described in pars 12 to 18. of this memoir, are caused by contiguous cilia; though I have not yet succeeded in demonstrating the latter. It is certainly a remarkable state of the blood-disc, however, which admits of such changes in its form.—November 1840.

The Chorion formed of Cells derived from Corpuscles of the Blood.

20. When the ovum is sought for in the Fallopian tube in the manner recommended in my "Second Series" on Embryology (*l. c.*, par. 313.), it is very common to find, in the mucus, patches of more or less altered blood-corpuscles. Plate XXIX. fig. 6. presents a minute portion of one of these patches, from the Fallopian tube of a Rabbit killed twelve hours *post coitum.* Many of the corpuscles (α), still flat, had undergone little change besides being pressed together into six-sided figures. Others (β) had become orange-shaped, highly refracted light, and presented in their interior a brilliant object, which in some instances (γ) was seen to be not central, but situated on one side. The diameter of the objects β was in general rather less than that of the unchanged corpuscles α. Whether this difference in diameter was referable to the change from a flattened to the more globular form, which would perhaps be sufficient to explain it[†],—or whether an outer covering (present in α) had disappeared in β,—I do not know; but the occasional presence of extremely minute granules or globules around such objects (ε), leads me to think it very possible that the disappearance in question does take place. If the figure be closely examined, and more particularly on the left side, transition states will be observed between the unaltered corpuscles α, and the cell (for such it may now be termed) β. The figure presents several cells (δ) in which a further change had taken place. They had become elliptical.

21. In Plate XXIX. fig. 7. are seen blood-corpuscles, now cells, from the Fallopian tube of a Rabbit killed fourteen hours *post coitum.* Some of these (δ) were in a state resembling that of δ in fig. 6. Others had enlarged, and presented processes or arms. When viewed singly and highly magnified, such objects appear yellowish; an accumulation of them, seen by the unassisted eye, or with a low magnifying power, is blood-red.

22. I formerly showed[‡] that during the passage of the ovum through the Fallopian tube, there rises from the thick transparent membrane (*f*) a thinner membrane. The latter was traced from stage to stage up to the period when villi form upon it, and thus ascertained to be the incipient chorion.

23. In a later paper[§] I stated that the thin membrane in question (the incipient chorion) is formed of cells, and that these are not cells of the ovarian so-called "disc," but newly-arisen objects, the nature of which more particularly would be made known in a future paper.

24. If now my last memoir be referred to[§], it will be found that the cells represented in Plate XXVIII. fig. 252 and 253. of that memoir, as forming the incipient chorion, have the same appearance as some of those in Plate XXIX. fig. 7. of the

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[†] It did not escape the notice of HEWSON, that the diameters of the red particles of human blood diminish from the particles becoming spherical, *l. c.*, pp. 18, 19.

[‡] Researches in Embryology, Second Series, *l. c.*, pars. 172. 222. Plate VI. fig. 104. *a* and β.

[§] Researches in Embryology, Third Series, *l. c.*, pars. 370 to 373.

present paper. And I confirm the statements made on that occasion; namely, that the cells send out processes or arms which interlace; that the contained pellucid object seems to enter into the processes or arms; that it is by a coalescence of the cells that the incipient chorion is formed; that the additions of cells appear to be continued up to the period when villi are produced; and that the villi themselves are probably formed out of the same kind of cells. It remains to add, that the cells in question, delineated in that paper, not merely have the same appearance, but are identical with those in Plate XXIX. fig. 7. of the present memoir: in other words, that the chorion is formed of cells which are altered corpuscles of the blood.

25. In Plate XXIX. fig. 8. are seen some of the very earliest traces of the formation of the chorion. The cells (g^1) of the tunica granulosa were described on a former occasion[†], as becoming club-shaped and connected with the membrane f by their pointed extremities alone, after the fecundation of the ovum. Such is the form and position of the cells g^1 exhibited, for the most part in outline, in this figure. One purpose answered by the changes just mentioned as presented by the cells g^1, seems to be that blood-corpuscles (*cho.*) find their way between them, and have space for applying themselves to the membrane f, while this membrane continues to be protected by those cells[‡]. In fig. 8. several blood-corpuscles (*cho.*) are seen to have occupied the latter situation, where, in some instances, they appear to effect the alterations in their form above described[§]. Three of them, it will be observed, had become cells, and two were in the same stage as some of those in fig. 7, having begun to send out processes or arms[||].

26. For the announcement that the chorion is formed by corpuscles of the Blood, physiologists, I apprehend, are not prepared; it being the generally received opinion that the formation and the nourishment of organs are effected through its fluid part[¶]. But the next section records facts which, if established by future observation, involve more important consequences.

Muscular Fibre formed of Cells derived from Corpuscles of the Blood.

27. The latest researches, which have been published, on the mode of origin of muscle, are I believe those of VALENTIN and SCHWANN.

[†] "Third Series," *l. c.*, par. 345.

[‡] Which also may afford fluid for the imbibition of the chorion. The protection above referred to is possibly essential during the transit of the ovum into the Fallopian tube.

[§] In other instances those alterations occur before the blood-corpuscles take their places on the ovum.

[||] In Insects, a structure supposed to be analogous to the chorion of Mammalia, is often found to present itself in the ovary, and it "not rarely exhibits an elegant delineation consisting of flat coalesced cells." (R. WAGNER, A. Encycl. d. W. u. K. Erste Section, XXXII. "Ei," p. 4.)

[¶] An eminent physiologist, however, has recently remarked: "What becomes of the blood-corpuscles,—whether they are transformed,—whether entirely or in part they are here and there deposited,—whether they dissolve, &c. has not been ascertained; we are reduced to mere hypotheses." (R. WAGNER, Beiträge zur vergl. Phys. H. II. S. 54.

28. "Muscular fibre," says VALENTIN, "arises***out of the jelly-like formative mass ***in the following manner: Long before separate muscular fibres are perceived, the globules of the primitive mass are seen arranged in longitudinal lines.***The granules ["globules"] now appear to approach one another, and in single places entirely—in others only on one side—to coalesce and unite into *one* transparent mass. By this means there arise threads, which in many places have a necklace-like appearance; in others are less distinctly notched, and often notched only on one side, the other side being straighter. Subsequently the thread loses every trace of granule ["globule"] or division, and becomes uniformly transparent, defined, and cylindrical.***Thus the muscular fibre continues when normal until about the period of the sixth month [of the fœtus], except that its substance becomes somewhat more opake and its cohesion closer. In the sixth month I have recently discerned on these fibres the first traces of transverse striæ, and hence (having now at command one of the best instruments of PLÖSSL) must retract the statement I formerly made, that these transverse striæ are entirely absent in the embryo. These transverse striæ however, during the whole of fœtal life are situated further apart, and discernible only with a clear light and high magnifying power.***From the period at which the muscular threads become transparent and uniform, there accumulate between them masses of round or roundish globules, which are somewhat larger than the blood-corpuscles—viz. 0·000407 Paris line. ***The muscular fibres are formed first, and subsequently their fibrillæ [contained within the fibres].***The younger the embryo is, the coarser are the elementary parts [of muscle].***We have above remarked that from the period at which the muscular fibre becomes uniform and transparent, globules accumulate in large number. Subsequently they diminish, and with the jelly-like mass—which holds them together—enter into the formation of the mucous tissue. This however unites—not the fibrillæ but—the fibres†."

29. More recently, and with reference to the doctrine of "cells," the same physiologist has communicated his views in the following words: "As soon as these [muscular fibres] appear in the fibrous form, there are seen in them round, very pale nuclei, which lie near together. From this it may be inferred, that here the cells arrange themselves likewise longitudinally, but coalesce immediately with one another without being drawn out into fibrillæ. This conjecture is confirmed by the fact that such an embryonic muscular fibre presents itself perfectly pectinate, as a conferva-fibril with a nucleus in each cell. This pectinate object, however, I have not hitherto so observed, as to have convinced myself of its complete natural conformity. There usually occur two circumstances which either call it forth or make it more distinct: 1. There follow the regular indentations of the muscular fibres, so that between two there always lies a regular nucleus. 2. On the transverse lines, which call forth the pectinate divisions, there lie very minute molecules with opake contours and a

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† Entwickelungsgeschichte des Menschen mit vergleichender Rücksicht der Entwickelung der Säugethiere und Vögel, 1835, pp. 267. 268.

transparent centre, regularly and more or less transversely arranged in lines. The pellucid nucleus is in the interior of the hollow muscular fibre, and often projects in part or wholly when the latter is divided. Subsequently it becomes less and less easily recognizable. Within the muscular fibre there present themselves longitudinal fibrillæ, and soon afterwards transverse striæ. That in the interior of the muscular fibre the cavity remains, seems to be confirmed by my already communicated observation†, that the ends of divided living muscular fibres often become turned inside outwards.‡"

30. Schwann's views on the mode of origin of muscle have been published at length in his late work§. They have since appeared in the following condensed form: "According to the observations of Valentin, muscles arise out of globules, which apply themselves to one another in rows and then coalesce into a fibre, which represents the primitive muscular *fasciculus*. The fibre so arisen is a hollow cylinder, and in its cavity there lie near together the nuclei of cells (Plate XXX. fig. 18. α.). It is hence probable that the globules of which the fibre is composed were hollow, that is cells, and that the cell-nuclei in this cylinder are the nuclei belonging to those *primary* cells. The earlier process, which I have not observed, must thus have been the following: The (hollow) globules or *primary* cells applied themselves to one another in a row, or coalesced to form a cylinder; and then the partitions—by which the cylinder must have been divided—became absorbed. The nuclei are flat, they lie within the cylinder, not in its axis, but in its wall. This cylinder or *secondary* muscle-cell—rounded off and closed at one extremity—continues to grow like a simple cell; but only in its length, for in breadth it does not increase at all, but rather diminishes. The longitudinal growth, however, does not take place merely at the extremities, but in the whole extent of the cylinder; as is seen from the cell-nuclei—which at first lie near together—separating from one another, and even becoming much elongated themselves. Thus the muscle-fasciculus α (Plate XXX. fig. 18.) becomes converted into β. There now occurs the deposit of another substance upon the inner surface of the cylinder-wall,—that is [upon the inner surface of] the cell-membrane of the secondary muscle-cell,—whereby the wall becomes thickened and the cavity of the cylinder reduced in size (compare the fibre γ with β). That the thickening of the wall is not a thickening of the cell-membrane itself, as in cartilage, follows from the fact that the cell-nuclei do not become pushed towards the cavity of the cylinder, but remain lying at the outer part, in the situation they occupied before the secondary deposit began. This is shown in δ. The secondary deposit continues until the cylinder is entirely filled. The deposited substance becomes converted into very fine fibrillæ, which run longitudinally in the cylinder. These are the primitive muscle-*fibres*. They thus together form a bundle—the primitive muscular fasciculus—which

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† Hecker's Neue Annalen, II. 71.

‡ Valentin, in R. Wagner's Lehrbuch der Physiologie, I. pp. 137. 138.

§ Mikroskopische Untersuchungen, &c.

is inclosed by a peculiar structureless wall, the cell-membrane of the secondary muscle-cell[†]."

31. Such then are the latest published views on the mode of origin of muscle. I have now to record facts which in some of the main points seem to confirm these views, and to supply further information regarding early periods in the formation of muscular fibre. But should they be found sufficient for these purposes, they will solve a problem of no common interest, and this in a most unexpected manner.

32. The objects in Plate XXX. fig. 17. were found lying together in mucus pressed from the Fallopian tube of a Rabbit killed ten hours *post coitum*. These mixed objects viewed *singly* in the microscope, had the same colour as the corpuscles (red particles) of the Blood,—viz. a yellowish colour. *Accumulations* of such objects—which frequently present themselves—appear blood-red.

33. We have seen a gradual transition of blood-discs into cells for the formation of the chorion,—as in Plate XXIX. figs. 6, 7. If now the objects in Plate XXX. fig. 17. be closely examined and compared with one another, I think it will be difficult to resist the conviction that there is an equally gradual transition from unchanged blood-discs to cells entering into the formation of certain necklace-like fibres in the figure. The question then is, what are these fibres which blood-discs form?

34. In describing the mode of origin of muscle, VALENTIN remarks[‡], that globules approach one another and coalesce to form threads, which in many places have a necklace-like appearance, but subsequently lose the traces of division and become cylinders. Could a more appropriate description have been given of the mode of origin of the fibres in my figures 14, 15, 16, 17[§]? SCHWANN conjectures[‖] that the globules now referred to as having been observed by VALENTIN, are cells; that these coalesce to form a secondary cell, that is, the cylinder; and that the nuclei contained in the cylinder are the nuclei of the primary cells. He found the nuclei flat, and not in the axis of the cylinder but in its wall. My observations realise these conjectures of SCHWANN, and the figures just referred to attest the accuracy of his observations. I would here compare my fig. 15. with δ of fig. 18., borrowed for the sake of comparison from SCHWANN, and exhibiting a later stage; and if several objects in my

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[†] SCHWANN, in R. WAGNER's Lehrbuch der Physiologie, I. pp. 140, 141. He adds: "A process entirely analogous to that which forms muscle is in operation, according to MEYEN, in the cells of the inner bark of trees. Here also there arise simple cells, which apply themselves to one another in a row, and through coalescence at the points of contact of the cell-membranes, and absorption of these coalesced partitions, become converted into a *secondary* cell, the wall of which thickens from a secondary deposit. The only question is, whether the substance which produces this thickening consists of longitudinal fibres" [fibrillæ], p. 141.

[‡] See the quotations from this author, pars. 28. 29.

[§] The objects in all these figures were pressed from the Fallopian tube, which it will be recollected becomes muscular at the period to which these observations have reference. Figs. 14 and 15. represent a minute portion only (merely the extremity), of a very considerable mass of fibres.

[‖] See the quotations from this author, par. 30.

fig. 17. be compared with γ of fig. 18., taken from that author, a further correspondence will be observed. But it is not needful to refer to the observations of others, since the objects figured by myself *were obviously muscular fibres* (the future fasciculi) in the earliest stages of formation. There is therefore, it appears, a direct transition of blood-discs into the elementary parts of muscle.

35. My observations have not extended farther than the condition $\gamma\gamma$ of fig. 17.—for they were almost entirely incidental;—so that I am unable to state the mode of origin of the fibrillæ within the cylinder. But certain facts communicated in my Third Series of Researches in Embryology, may perhaps be applicable here.

36. It was there shown that a nucleus, after passing to the centre of a cell, resolves itself into the foundations of new cells. I would suggest that the nucleus may *thus* be the source of that "secondary deposit" described by Valentin and Schwann as thickening the membrane of the cylinder; and am the more disposed to think this possible, from the observations of Schwann on the frequent metamorphosis of cells into fibres. The existence of the longitudinal fibrillæ might perhaps be thus explained, for Schwann remarks, that these fibrillæ are formed out of the "secondary deposits."—This suggestion corresponds to one offered in my last memoir on the possible mode of origin of spiral fibres and other secondary deposits in vegetable cells.

37. It is not needful, however, that the central portion of a nucleus should leave the membrane of its cell, before the resolution of the free portion of such nucleus; of which the germinal spot in its last stages affords a remarkable example[†]. I regard the pellucid objects in the cells Plate XXX. figs. 15. 17[‡], as occupying the place of the pellucid centres of the blood-corpuscles.

38. In the cells fig. 16. no such pellucid objects were observed at the surface. But the cells presented a lighter central space, which I believe to have corresponded to the pellucid objects in question,—these having passed to that situation. And if the pellucid objects here seen are the seat of changes analogous to those presented by the mysterious centres of nuclei elsewhere[§], it is not difficult to conceive the mode of origin of the "secondary deposits" above referred to[||]. The object $\beta\beta$ in fig. 17. presented a state apparently rather more advanced than those in fig. 16. The cells, however, had not coalesced. In $\gamma\gamma$ of fig. 17. the coalescence had more or less completely taken place; and it is deserving of notice, that what in $\beta\beta$ appeared the separate pellucid objects in question, had in $\gamma\gamma$ also coalesced, or seemed about to coalesce, to constitute the medullary portion of the cylinder. From the state of the fibre $\gamma\gamma$, it appears also that secondary deposits are in progress before the cylinder is fully formed.

[†] "Third Series," *l. c.*, pars. 327, 328.

[‡] And also those in Plate XXIX. fig. 7, &c.

[§] "Third Series," *l. c.*, pars. 375 to 395.

[||] That the pellucid object in the altered blood-disc really undergoes these changes, is to be inferred from Plate XXX. fig. 20. (par. 44.)

39. The purpose answered by the pellucid objects retaining in some instances a peripheral locality (fig. 18. δ. from SCHWANN), is no doubt an important one; but on this subject I do not hazard a conjecture.

40. The blood-corpuscles when passing into cells for the formation of muscular fibre, *are darker in colour* than those destined to form the chorion. There seems to occur in them *an increase of red colouring matter* (par. 43.).

41. The masses of globules seen by VALENTIN (par. 28.) to accumulate between the muscular threads,—globules which were "round or roundish" and "somewhat larger than the blood-corpuscles,"—I would suggest may really have been blood-corpuscles, which had assumed a globular form, and increased in size in the manner above described. VALENTIN, however, states that the globules in question entered into the formation of the "uniting mucous tissue[†]."

42. In connexion with the fact now recorded, that muscular fibre is formed of corpuscles of the blood, an observation may be referred to which has been mentioned by several authors[‡]; namely, that of a disposition to run into combinations, and form objects compared by HEWSON to rolls of coin. I find it very usual for this appearance to arise in blood obtained by a puncture (as of the finger), and to which no addition has been made.—R. WAGNER mentions that in blood taken from the heart of some of the Invertebrata—*Unio* and *Anodonta*—when the coagulating fibrin makes its appearance, blood-corpuscles are seen—*often grouped necklace-like*—around it.

43. Others have supposed muscular fibre to be formed by the blood-discs; but I am not aware of any facts having been observed which warranted the supposition. It is remarkable that a conjecture on this subject in one of the papers of Sir EVERARD HOME[§] should have approached so near the truth. His conjecture was, "That the globules may be the part of the blood, out of which the muscular fibres are principally formed[‖]." Between Sir E. HOME's *observations* and my own, however, it will be perceived that there are material differences. For instance, he remarks, "When the globules of the human blood lose the colouring matter, they continue floating in the serum, and are seen to have an attraction towards one another so as to coalesce, uniting themselves together[¶]." In the altered corpuscles—that is, cells—which I saw uniting to form muscular fibre, the colour—so far from having disappeared—seemed (as already mentioned) to have become more intense (par. 40.).

State of the Blood-corpuscles during Vital Turgescence of the Vessels.

44. The appearance presented by the capillaries in highly vascular conditions of the internal generative organs, is remarkable. An idea of it may be obtained from Plate XXX. fig. 20, taken from a portion of the inner surface of the infundibulum of the

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[†] Entwickelungsgeschichte, &c., S. 269.

[‡] HEWSON (*l. c.*, p. 28.), HODGKIN and LISTER (*l. c.*, p. 436.), R. WAGNER (*l. c.*, p. 6.).

[§] The Croonian Lecture, Philosophical Transactions, 1818, p. 172.

[‖] Ibid. pp. 174, 175.

[¶] Ibid. p. 174.

Fallopian tube in a Rabbit killed 5½ hours *post coitum.* The vessels were *filled* with blood-corpuscles apparently to the exclusion of surrounding fluid. The corpuscles, in depth of colour, cell-like form, and general appearance, resembled those above described as entering into the formation of muscular fibre; but in most of them the usual place of the contained pellucid object was occupied by a substance which was obscure and dark, though presenting in some of the corpuscles a pellucid central point. This, however—from observations on the varying state of the interior of nuclei, and the continual origin there of fresh objects, recorded in my "Third Series"—so far from constituting a difference, seems to furnish a confirmation of my views as to the nature of the pellucid objects in question (par. 38.).—The largest vessel in this figure measured in external diameter $\frac{1}{200}'''$. But I have seen a vessel so filled, of many times this size.

45. The description now given of fig. 20. is applicable to the states of capillaries constantly observed at the period in question. The figure shows, that the corpuscles, having assumed a more or less globular or elliptic form, so completely fill their vessels as to be compressed into polyhedral shapes, and even to produce inequalities in the calibre of their vessels. When examined immediately after death, the contents of such vessels have in some instances exhibited here and there a slight degree of motion.

46. The vessels constituting a network under the epithelium-cells which carry cilia, and present the frill-like appearance in the outline fig. 19[†], are filled with corpuscles in the above altered states[‡]. In other parts (fig. 21.) vessels are found so filled, which do not exhibit the same immediate connexion with the cilia-bearing cells.

47. I have seen both in the Fallopian tube and on its fimbriated extremity, a curious network (fig. 22.), apparently formed by the coalescence of blood-corpuscles, which, like those entering into the formation of the chorion, seemed for this purpose to have sent out processes or arms. The finest ramifications in arborescent states of the capillaries like that in fig. 21, have sometimes appeared to pass into a network of this kind[§].

48. The above-described condition of the blood-corpuscles during vital turgescence of the vessels, I think deserving of consideration, in connexion with many of the phenomena attending local accumulations of blood, both in health and in disease; and more especially with reference to increased pulsation, the exudation of colourless fluid, and the heat and redness of inflamed parts.

49. Incipient epithelium-cells often present appearances which almost suggest the idea that these too are changed corpuscles of the blood. Compare in Plate XXIX. figs. 10, 11 with fig. 12. It is at least difficult to draw a line by which the two can

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[†] See the explanation of the Plates.

[‡] It is a part of fig. 19. which is represented on a larger scale in fig. 20.

[§] On one occasion I observed a vermicular motion in a minute portion of such a network.

be distinguished, either in colour, form, or general appearance. (The epithelium-cells in question are frequently observed to lie in the same direction, their long axes being parallel.)

50. But if the great mass of the soft parts, muscle, is formed of corpuscles of the blood, how many tissues are there which they may not form?[†]

51. We are indebted to Schwann for the very important discovery, that "for all the elementary parts of organisms there is a common principle of development;" the elementary parts of tissues having, as he has shown, a like origin in cells, however different the functions of those tissues. The facts made known in the present memoir, if established by future observation, will not only afford proofs of the justness of the views of Schwann, but they will farther show that objects having all the same colour, form, and general appearance, namely, the corpuscles of the blood, enter immediately into the formation of tissues which physiologically are extremely different. We have seen some of these corpuscles to arrange themselves into muscular fibre, and others to become metamorphosed into constituent parts of the chorion. It is not, however, more difficult to conceive objects so much alike undergoing transformations for purposes so different, than it is to admit a fact made known by two of my preceding memoirs[‡]; namely, that the nucleus of a cell having a central situation in the group which constitutes the germ, is developed into the whole embryo, while the nuclei of cells occupying less central situations in the group, form no more than a minute portion of a membrane[§]. It is known that in the bee-hive, a grub is taken for a special purpose, from among those born as workers, which it perfectly resembles until nourished with peculiar food, when its development takes a different course from that of every other individual in the hive.

[†] "The nerves," says Schwann, "appear to arise in the same manner as the muscles; namely, through coalescence of primary cells in contact with one another and in a line, by which there is formed a secondary cell. But the primary nerve-cells have not been with certainty observed, because—so long as they are primary cells—they are not to be distinguished from the neutral cells, out of which arises the whole organ.***The fibres [secondary cells] are pale, granulated, and***hollow. There now takes place, as in muscles, a secondary deposit upon the inner surface of the fibre-wall, that is, upon the inner surface of the membrane of the secondary nerve-cell.***On the appearance of this deposit the cell-nuclei are usually absorbed; yet single ones continue, and then lie externally between the [deposited] substance and the [secondary] cell-membrane,***as in muscles. The remaining cavity of the secondary cell appears to be occupied by a tolerably firm substance, the band discovered by Remak." (Schwann in R. Wagner's Lehrbuch der Physiologie, I. pp. 141, 142.) Should it be found that nerves too are formed of blood-corpuscles, this band of Remak may perhaps be constituted by coalesced objects similar to those apparently uniting to form the central substance in the muscle-cylinder (par. 38.), and which appear to be the essential part of altered corpuscles of the blood.—"The external appearance of tendons in the embryo," says Valentin, "is reddish, and not unlike the pale muscle-structures." (Entwickelungsgeschichte, p. 270.)

[‡] Researches in Embryology, Second and Third Series, *l. c.*

[§] Which I provisionally called the amnion.

52. Explanation of the Plates.

PLATE XXIX.

Fig. 1. Blood-corpuscles in fluid collected on the fimbriated portion of the Fallopian tube in a Rabbit killed eleven hours *post coitum*. α. Usual state, or but little altered; β. incipient division into globules; γ. more advanced stage in this division (paragraphs 2. 3. 4.).

Fig. 2. Blood-corpuscles in fluid collected on the ovary in a Rabbit killed seven hours *post coitum*. α. Usual state, or but little changed. The corpuscles in this figure which are not distinguished by a letter, present various stages in the division into globules, incipient in β of the preceding figure. Among the corpuscles are some in which the pellucid central portion is bounded by a dark line. Several are represented as viewed more or less laterally. In δ, the division has proceeded so far as to present the appearance of distinct though still adherent globules (par. 2 to 5. 8.). ε. Objects found with the foregoing (see par. 10.).

Fig. 3. Blood-corpuscles in fluid collected on the fimbriated portion of the Fallopian tube in a Rabbit killed five hours *post coitum*. These corpuscles were in motion. Those at α resembled several in fig. 2. β Appeared to be horizontally revolving on its axis. The corpuscles on the right side of β seemed to consist of a central and a peripheral portion, more or less corresponding in appearance to those at α; but in most instances the peripheral portion was less distinctly separated into globules, and in all of them the form was undergoing rapid and incessant change. γ. The central pellucid fluid had separated into three portions, and the motions of the entire object were such as to suggest the idea of its being about to undergo a like separation. The motions of these corpuscles were observed two hours and a half after death (par. 12 to 19.).

Fig. 4. Blood-corpuscles in fluid collected on the fimbriated portion of the Fallopian tube in a Rabbit killed thirteen hours *post coitum*. These, when first observed, were rapidly and incessantly changing their form. When their motions ceased they retained the forms exhibited in the figure. Their pellucid centres were scarcely, if at all, seen while the motions continued. Sometimes they appeared almost to separate into two portions, and then recover their previous form. The motion ceased gradually, gentle undulations having been the last change observed (par. 12 to 19.).

Fig 5. Several of the appearances presented by a blood-corpuscle observed changing its form as above described. The pellucid fluid, sometimes central (α),

seemed at other times on one side (β), and at others as though divided into several parts (γ). Taken from fluid collected on the fimbriated portion of the Fallopian tube, in a Rabbit killed $5\frac{1}{2}$ hours *post coitum* (par. 12 to 17.).

Fig. 6. Blood-corpuscles from the Fallopian tube of a Rabbit killed twelve hours *post coitum*. Many of them (α) flat, and in a condition little changed; others (β) become orange-shaped cells, a portion of their interior pellucid. In some (γ) the pellucid portion was seen to be, not central but, on one side. Certain of them (δ) had become elliptical. Some (ε) presented very minute adherent granules or globules (pars. 20. 21. 33.).

Fig. 7. Blood-corpuscles—now true cells—from the Fallopian tube of a Rabbit killed fourteen hours *post coitum*. Some of them (δ) resembled δ in fig. 6. Others had considerably enlarged, and sent out processes or arms. Such as these enter into the formation of the chorion. When viewed singly, the objects in this figure—with the exception of the pellucid portion which each presents—appeared yellowish; an accumulation of such objects is blood-red (pars. 21. 24. 25. 33.).

Fig. 8. Outline of part of an ovum of twelve hours, and measuring $\frac{1}{14}'''$, from the Fallopian tube. The cells of the tunica granulosa (g^1)—also for the most part in outline—had become club-shaped, and were in contact with the membrane *f* by their pointed extremities alone. The object of this figure is to show some of the very earliest traces of the formation of the chorion. Blood-corpuscles (*cho.*), having found their way between the cells g^1, apply themselves to the membrane *f*, and undergo the changes elsewhere described. Three of these corpuscles had passed into the state of cells, the contained pellucid object being at the surface; and two of these cells had begun to send out processes or arms (par. 25.). *e.* Proper membrane of the substance surrounding the germinal vesicle. Between this membrane and the membrane *f* there was a space, filled with transparent fluid.

Fig. 9. Blood-corpuscles in fluid collected in the infundibulum of the Fallopian tube of a Rabbit killed in the state of heat.

Fig. 10. Altered and now spheroidal blood-corpuscles in fluid collected in the infundibulum of the Fallopian tube, in a Rabbit killed four hours *post coitum* (par. 49.).

Fig. 11. Altered blood-corpuscles in fluid collected on the fimbriated portion of the Fallopian tube, in a Rabbit killed in the state of heat (par. 49.).

Fig. 12. Epithelium-cells, found with the blood-corpuscles in the preceding figure, and having very much the appearance of being formed out of such corpuscles. Some of them were beginning to send out a process, and they were all lying in nearly the same direction (par. 49.).

Fig. 13. Another form of epithelium-cells—formed of blood-corpuscles (?)—found with those in the preceding figure. Colour yellowish, except the contained pellucid objects. Their long axes parallel.

PLATE XXX.

Fig. 14. Blood-corpuscles—now cells—arranging themselves to form muscle. Found with an ovum of ten hours, taken from the Fallopian tube (par. 34.).

Fig. 15. A portion of the same, more highly magnified. The pellucid objects contained in the blood-corpuscles (now cells) in many instances were seen to be situated—not in the centre but—on one side. When viewed singly, these objects appeared yellowish; in a mass, blood-red (pars. 34. 37.).

Fig. 16. Blood-corpuscles—now cells—arranging themselves to form muscle. Some of them remarkably elongated (pars. 34. 38.). Found in the Fallopian tube of a Rabbit killed eleven hours *post coitum*.

Fig. 17. Blood-corpuscles (α, γ, δ), and portions of muscle ($\beta\beta, \gamma\gamma$) formed of blood-corpuscles, found with the objects figs. 14 and 15. This figure presents several transition states between the unchanged blood-disc α, and the necklace-like arrangement of cells $\beta\beta$. In the latter, the contained pellucid object had a central situation, but the cells had scarcely coalesced. $\gamma\gamma$ Presents a more advanced state. Here the cells had more or less coalesced into a cylinder, and the contained pellucid objects together formed, or seemed about to form, the medullary portion of the cylinder. In this figure are also objects resembling fig. 15. (pars. 32 to 35. 37. 38.)

Fig. 18. From SCHWANN (in R. WAGNER'S "Icones Physiologicæ," Tab. XII. fig. 4.). α to δ, "Different stages in the development of muscle" (pars. 30. 34. 39.).

Fig. 19. Outline of capillaries as seen in a portion of the infundibulum of the Fallopian tube, taken from its inner surface, in a Rabbit killed 5½ hours *post coitum*. These vessels were filled with blood-corpuscles in the state represented in fig. 20. At the lower part of this figure (fig. 19.) are epithelium-cells carrying cilia. These epithelium-cells are arranged parallel to one another, and perpendicular to the general direction of the capillary vessels. The small extremity of the epithelium-cells is directed towards the capillaries. Whence their frill-like appearance (in the figure), and the great extent of their ciliary surface. External diameter of the largest vessel $\frac{1}{200}'''$. 100 *diam.* (par. 46.)

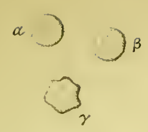
Fig. 20. A portion of the capillary vessels in the preceding figure, more highly magnified (300 *diameters*), to show the appearance of the blood-corpuscles with which they were filled. The blood-corpuscles presented in their

interior an object, which in most instances was more opake (redder) than the remainder of the corpuscle ; but in some of the corpuscles the corresponding situation was occupied by a pellucid object (pars. 44. 45.).

Fig. 21. Outline of capillaries from the inner surface of the infundibulum of the same Rabbit, and filled with blood-corpuscles in the same condition as those in fig. 20 ; but not related to ciliated epithelium-cells in the manner exhibited in fig. 19. The external diameter of the largest vessel measured $\frac{1}{100}'''$. 100 *diam.* (pars. 46. 47.)

Fig. 22. Network formed apparently of altered blood-corpuscles, the arms of which (see Plate XXIX. fig. 7.) have coalesced. Found with the objects in Plate XXIX. figs. 11. 12. 13. (par. 47.).

Corpuscles of the Blood.



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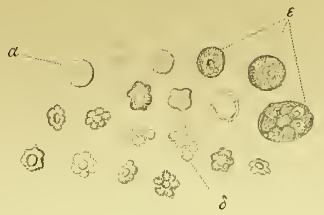

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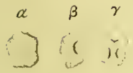

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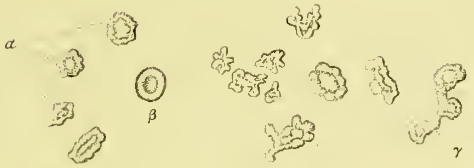

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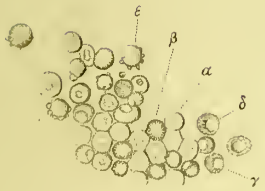

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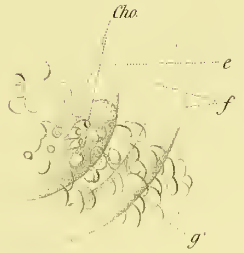

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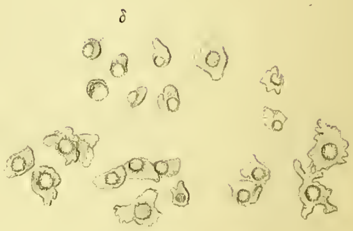

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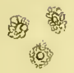

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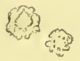

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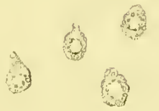

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All the Objects are from the Rabbit.—The diameters magnified vary from 200 to 400.

Figˢ. 1 to 5. Blood-corpuscles, more or less altered (ε Fig. 2?).

Figˢ. 6 to 8. Blood-corpuscles, becoming Cells for the formation of the Chorion.

Figˢ. 9 to 11. Altered Blood-corpuscles.

Figˢ. 12. 13. Epithelium-cells — (Altered Blood-corpuscles?)

Ad Nat. del. Martin Barry.

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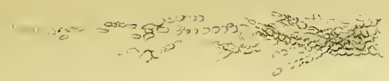
Corpuscles of the Blood.



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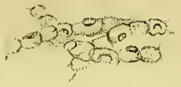

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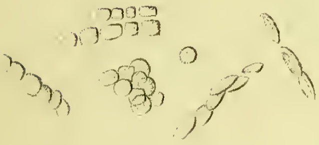

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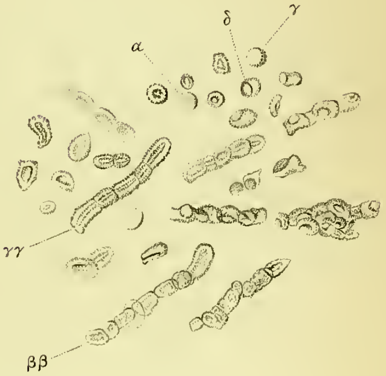

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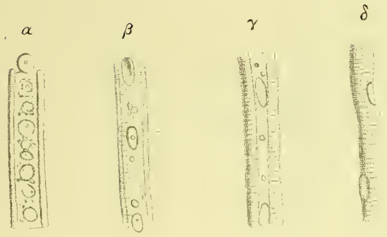

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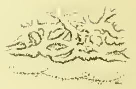

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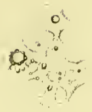

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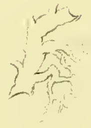

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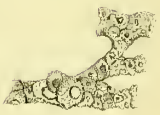

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(All the Figures are from the Rabbit, except fig. 18.)

Figs. 14 to 17. Blood-corpuscles becoming Cells, which are forming Muscular Fasciculi.
Fig. 18. Muscular Fasciculi in a more advanced state. (from Schwann.)
Figs. 19 to 21. Capillaries filled with altered Corpuscles of the Blood.
Fig. 22. Network, formed of Blood-corpuscles?

Ad Nat. del. Martin Barry.

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Dr. W. Baly
with the Author's best respects —

ON

THE CORPUSCLES

OF

THE BLOOD.

(*Part II. and III.*)

BY

MARTIN BARRY, M.D., F.R.SS. L. and E.

From the PHILOSOPHICAL TRANSACTIONS.—PART II. FOR 1841.

LONDON:

PRINTED BY R. AND J. E. TAYLOR, RED LION COURT, FLEET STREET.

1841.

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XVI. *On the Corpuscles of the Blood.—Part II.* *By* MARTIN BARRY, *M.D., F.R.SS. L. and E.*

Received January 13,—Read January 14, 1841.

SOME time since, I laid before the Royal Society a few facts, which had incidentally fallen under my notice, connected with the red particles or corpuscles of the blood[†]. Those facts were of a character which led me to expect that the farther prosecution of the subject might be rewarded by the discovery of others; although, in a field of physiological research so often traversed from the days of MALPIGHI and LEEUWENHOEK down to the present time, I could hardly expect to succeed in making any addition to the exact description given by some able writers of the present day, regarding the appearance of these corpuscles. But some ideas suggested during the examination of objects figured in the memoir just referred to, induced me to make the blood-corpuscles the subject of direct inquiry with reference to their mode of origin, and certain changes which they undergo.

It will be remarkable if the mammiferous ovum, which, because of its minuteness and the supposed difficulty of obtaining it, had been generally considered beyond the reach of satisfactory observation, should now become the means of studying, not merely other ova, but certain processes by which nourishment is communicated, and the growth of the body effected at all future periods of life. Such, however, I think will really be the case.

For the sake of avoiding a great deal of repetition, I shall at present confine myself very much to the general results; referring, for a particular description of the figures which accompany this memoir, to the minute explanation of them separately given (par. 87.). I may here state that, instead of perplexing the reader with measurements expressed in arithmetical figures, I have thought it preferable in all the drawings to represent the lines of the micrometer on which the objects lay; which lines are more particularly referred to at the foot of Plate XVII. I have taken the utmost care to represent faithfully the appearances presented by the objects examined; and an inspection of them will show that the undertaking occupied no small portion of time. Some of the differences between the drawings now presented and those of previous observers, are, I think, to be attributed to my having used a greater degree of care in the removal, by the usual means, of a portion of the colouring matter from the corpuscle, where required (par. 72.). In other instances, however, where none of the colouring matter was removed, I am unable to explain the cause of the differences in our observations.

[†] Philosophical Transactions, 1840, Part II. p. 595.

53. A very superficial examination of the drawings, will suffice to discover the principal differences here referred to. It will be seen that the nucleus of the blood-corpuscle—usually considered, I believe, as a single object—is represented by me as composed, in some instances, of two, three, or even many parts; these having a constant and determinate form. The substance surrounding the nucleus is, I think, even by the latest observers, regarded simply as "the red colouring matter,"—forming the contents of what has been denominated the blood-cell. I find it not uncommon to be able to distinguish in this substance a great number of discs or cell-like objects; and, what is equally remarkable, to discern (in certain states of the corpuscle) an orifice in the delicate membrane by which this substance is surrounded. But it is not so much these facts to which I ask attention, as certain conclusions which they, with others, have enabled me to form.

54. In another memoir, also presented to the Royal Society[†], I was under the necessity of expressing opinions no less differing from those of very distinguished physiologists, on a subject of the first importance; affecting, as it does, every tissue of which organized beings are composed—the physiology of "cells." SCHLEIDEN had stated, that, after giving origin to the membrane of its cell, the nucleus has performed its chief office; and that, when it does not continue at the surface of the cell, the nucleus is "cast off as a useless member, and absorbed[‡]." SCHWANN had said, that, with the exception of fat-globules having in some instances, in fat-cells, been seen to arise out of it, he had never observed anything whatever to be produced by the nucleus of the cell[§]. My observations, on the contrary, showed the nucleus to have a higher office to perform than that of giving origin simply to the membrane of a cell; that, instead of being "cast off as useless, and absorbed," the nucleus is the source of new substance,—a centre for the origin, not only of the transitory contents of its own cell ("Zelleninhalt" of German authors), but also of the two or three principal and last formed cells destined to succeed that cell; and, in fact, that by far the greater portion of the nucleus, instead of existing anterior to the formation of the cell, arises within its cavity.—A separation of the nucleus into two or three parts, where previously observed—namely, in the globule of pus and mucus—had been attributed by GUTERBOCK, HENLE, and others, to a chemical reagent used in the examination—acetic acid[‖]. But, we saw that neither acetic acid nor any other foreign

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[†] Researches in Embryology. Third Series: A Contribution to the Physiology of Cells. Philosophical Transactions, 1840, Part II. p. 529.

[‡] SCHLEIDEN, Beiträge zur Phytogenesis. MÜLLER's Archiv, 1838, Heft II. p. 146.

[§] Mikroskopische Untersuchungen über die Uebereinstimmung in der Struktur und dem Wachsthum der Thiere und Pflanzen, 1838–9, p. 54.

[‖] HENLE, HUFELAND's Journal, Mai 1838, p. 62, pl. i. fig. 9–12.

substance is required to produce the separation in question; this separation being natural, apparently common to nuclei in general, and forming part of the process by which cells are reproduced. We found that young cells originate through division of the nucleus of the parent cell, instead of arising as a sort of "product of crystallization, in the fluid cytoblastema" of the parent cell, as since supposed by Reichert[†]. The so-called nucleolus had been described as a distinct object, existing before the nucleus. But, we saw the nucleolus to be merely one of a series of appearances arising in succession, the one within the other, at a certain part of the periphery of the nucleus; and continuing to arise even after the formation of the cell.

55. My later investigations, I have now the satisfaction of stating, confirm the opinions just referred to, as well as others which I formerly expressed, but which are not recapitulated here; and the object of the present paper is to show, that they admit of being extended to the corpuscles of the blood[‡].

56. The observations recorded in this memoir are based on an examination of the blood in all classes of vertebrated animals, in the embryo of Mammalia as well as that of Birds, and in some of the Invertebrata.

57. In certain states of the corpuscle of the blood its nucleus is single, like the central portion of the germinal spot in the germinal vesicle of the ovum. Such is the case at α in Plate XVIII. fig. 51. and at η in fig. 54. from Fishes, at α in figs. 49 and 50. from two of the Reptilia, at β in figs. 43 and 45. from the Bird, and in fig. 32. from the Mammal. In all the blood-corpuscles now referred to—which it will be seen are those of the four classes of vertebrated animals, including the two divisions of both Reptiles and Fishes,—the nucleus has a cavity or a depression; at the margin of which there occurs a high refraction of light. The appearance thus produced, seems to represent one of the states of the "nucleolus" of authors, in other cells.

58. The centre of the germinal spot undoubtedly communicates at a certain period with the exterior of the germinal vesicle; for strong presumptive evidence was brought forward, showing the introduction of some substance into the centre of this spot from the exterior of its vesicle. And, besides, I mentioned that in a certain

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[†] Das Entwickelungsleben im Wirbelthier-reich, 1840, p. 2.

[‡] They probably admit of being extended much farther. I cannot, indeed, but recognize in a paper by Professor Valentin, not merely dissent (in some instances at least) from the view above referred to,—that the nucleus is cast off as "*useless*,"—but also facts which go to corroborate some of my own observations; however little the conclusions at which I arrived, resemble those of the author now mentioned. See Müller's Archiv, 1840, Heft II. pp. 229, 230, and 235. The recent work of Reichert also, before referred to, contains observations respecting which I would make the same remark. This author, however, adopts the mistaken view, that the nucleus of the cell is absorbed. For, considering the germinal vesicle as a nucleus, he *therefore* supposes it to disappear (*l. c.*, pp. 102, 103). The "finely granular" and "globular precipitate" of Reichert, appearing around the nucleus, evidently arose from decomposition of the free portion of the nucleus (See my Third Series, *l. c.*, par. 391): to which cause seems referable the reduction he observed in the size of this object (*l. c.*, p. 91).

condition of the ovum, I had not been able to discern a continuation of the membrane of the germinal vesicle over the central portion of the spot. So likewise the corpuscle of the blood in certain states exhibits an orifice, by means of which there is a communication between the exterior of the corpuscle and the cavity in its nucleus.

59. The free portion of the germinal spot resolves itself into discoid objects—the foundations of cells; with which the germinal vesicle becomes filled. In like manner, the blood-corpuscle is seen filled with corpuscles of minuter size; presenting an appearance which I can attribute to no other than the same process. This is shown in the blood-corpuscle of the Fish at γ, fig. 52, at α and β, fig. 53, and at ε and ζ, fig. 54 —in that of the Reptile, ε, figs. 49 and 50—in that of the Bird, fig. 36 β, fig. 41 β, fig. 43 β, γ, fig. 45, and fig. 47.

60. The foundation of the new being in the mammiferous ovum, arising in the centre of the altered germinal spot—which centre, from this and other facts, I denominated the point of fecundation—we saw to consist of two discs; each of these discs giving origin to a cell. So also, in more than half the numerous figures accompanying this memoir, we find the same appearances in blood-corpuscles, including those of Man. (In certain states, the nucleus of the blood-corpuscle is composed of three or more discs, instead of two. Figs. 33, 34 γ, 41 β, 43 δ, 45 θ, ι, 52 γ, δ, 53 α, 54 ζ. Compare with the nucleus of a yelk-globule from an immature ovum of the Tiger in my Second Series on the Embryo†).

61. The two cells in question, in the ovum, at a certain period are set free; each being destined to give origin to others. Such also is the case with the corpuscles of the blood. See figs. 29, 30, 39, 41 γ.

62. The foregoing analogies are not confined to vertebrated animals; for I have met with some of them, at least, in three classes of the Invertebrata. See figs. 57, 61 and 62.

63. Such facts as these appear to warrant the conclusion, that the corpuscles of the blood are generated by a process essentially the same as that described in one of my former memoirs, as giving origin to those cells which are the immediate successors of the germinal vesicle, or original parent cell.

64. If the blood-corpuscles of Man in fig. 23 be minutely examined in the order in which they are alphabetically lettered, and in connection with the description separately given (par. 87),—and if they be then compared with a succession of appearances delineated in my former paper on the Corpuscles of the Blood‡,—I think it will be obvious that those appearances arose from the blood-corpuscle resolving itself into minuter objects, by a continuation of the same process as that through which, as we have just seen, it is itself produced.

65. Eighty years have elapsed since the ingenious Father Di Torre, after presenting to the Royal Society some rude but powerful lenses of his own preparing, afforded

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† Philosophical Transactions Part II. 1839, Plate V. fig. 87.

‡ *L. c.*, p. 595. Plate XXIX. fig. 2.

Sir F. H. E. Stiles opportunities for viewing human blood by means of lenses of the same kind; when the latter communicated to the Society his observations, or rather the observations of Di Torre, as confirmed by himself[†]. So little importance is attached, in the present day, to the observations of Di Torre, that in historical accounts of the blood-corpuscles, I believe it is usual to pass them by, as not deserving of notice: probably from an idea that his optical instruments were too imperfect. But I shall not hesitate to here transcribe a passage from those observations of Di Torre, although far from vouching for their entire accuracy.

66. "When," says the writer, "any of the globules [blood-corpuscles] happened to move with the serum in the most perfect focus,*** I could with great clearness distinguish the exterior and interior circumference of the ring, of which each globule [corpuscle] consisted; the interior one being bounded by a black line or shade next the perforation, exactly resembling that which bounded the exterior one,***. In such globules [corpuscles] I could easily observe the ring to be articulated, the transverse lines at the joints being very distinguishable. The figures of the articulations were various; in some they were roundish, so that the ring appeared like a bead necklace; in others, cylindrical, and of some length. The number of which the whole was composed, seemed uncertain, varying from two or three to six or seven; many of the rings were broke, either by some confinement of the talks [talc], or by beating against each other, which I saw them continually do; and by these accidents the joints of the rings were detached, and wandered about separately in great numbers; and indeed they appeared separable with as much ease as if they had been united by mere contact only. Some of the rings were broke into semicircles, others into greater or less portions, and others again divided into their constituent articulations, which in some places floated about single, and in others formed by their mutual attraction a lateral union, like the pipes of an organ. I must observe also, that these separated parts seemed to be hollow and transparent, and like inflated bladders, would easily yield, and change their figure, stretching or contracting themselves from round to oval and cylindrical, and *vice versâ*, as any lateral pressure in crouding [crowding] them along with the serum brought a constraint upon them. *** Although the articulation was not distinguishable in every globule, I think it was so in the greater part of them; and it is natural to imagine that the rest were articulated likewise, though they might not pass at the proper distance for its being distinguished[‡]."

67. Such were the observations placed on record by the Royal Society seventy-six years ago, which I had not read until fig. 23. of the present paper was nearly finished. As already stated, I do not believe they were accurate in all respects. But if the figure just mentioned be again referred to, it will be found that observations made by myself in 1840 and 1841, with an excellent instrument, while they very widely differ from those of late observers, confirm to a degree that is astonishing, some of the

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[†] Philosophical Transactions, 1765, p. 252.

[‡] *L. c.*, pp. 254, 255.

observations which had been made by Di Torre, with his rude and smoked lenses, in 1761. No one can feel more conscious than I do, how much we owe to Hewson for his researches on the corpuscles of the blood: but I think he erred in dismissing as valueless the remarks of the Italian observer.

68. I would add, once more referring to fig. 23, that the arrangement of the contents of the blood-corpuscle in the human subject, will be seen to coincide, in some instances, with its well-known usually biconcave form (pars. 73 to 76).

69. The form and internal state of the blood-corpuscle found in the adult of certain animals, very much resembles that existing only in the fœtal life of others. This will be obvious on an inspection of the drawings. That such resemblance is referable to uniformity in the mode of evolution, results from our whole experience on the reproduction of cells, as I explain it, and from facts above mentioned, showing that blood-corpuscles are generated by a like process; the difference between the condition of these objects in the embryo and in the adult of the same animal, being apparently referable to a difference in the degree of their development as cells.

70. An incidental observation may perhaps be mentioned here. The brain in the embryo of the Ox, at certain periods, appears to consist almost entirely of objects such as those in figs. 59 and 60; which, it will be seen, are composed of discs. Before the addition of acetic acid, such objects in many instances are surrounded by a halo, which seems to represent the membrane of a minute cell. If the objects now mentioned be compared with some of the nuclei of blood-corpuscles which I have figured, it will be found that there is a remarkable similarity between them.

71. On a review of the facts stated in the course of the present communication, the opinion I have been led to form, is that the mode of evolution of the minute mammiferous ovum is deserving of close attention in connection with some of the processes by which nourishment is communicated, and the growth of the body effected at all future periods of life.

Appendix.

The following additional remarks were kept out of the memoir itself, for the purpose of rendering it as simple and brief as possible.

72. The chemical reagent principally used in the investigations forming the subject of this paper, has been dilute acetic acid of the strength of distilled vinegar. I have found it an advantage to add this acid in a quantity so very small, as to be enabled to witness its gradual effect upon the contents of the blood-corpuscle. It has been by this means, in part, that I have discerned the interior of this object to be, to my astonishment, so different from that represented by previous observers.

73. Professor Müller remarks, "It is quite impossible to imagine the cause of the different forms of the red particles in the different classes of vertebrated animals. There are no similar elementary forms in the whole body[†]."

74. It will be obvious that I cannot agree with the eminent physiologist now mentioned, in the latter part of the quotation; the main object of this memoir having been to show that the blood-corpuscles are generated by a process of the same kind as that which I have elsewhere described. But I wish to ask attention in this place to the former part of the passage just quoted from Professor Müller,—as to the possibility of imagining the cause of the different forms of the red particles in the different classes of vertebrated animals; for, perhaps some of the accompanying delineations may assist us even here.

75. Dr. Young denied the existence of a nucleus in the corpuscle of human blood: Hewson believed it to be globular: Müller remarks, "And as this nucleus [of the blood-corpuscle] has under the microscope exactly the same appearance in the red particles of Birds and Fishes as in those of Amphibia, it would be expected to exist in those of Mammalia also. And although, on account of the minuteness of these bodies in Mammalia, it is more difficult to demonstrate the nucleus in them, I have with an excellent (Fraunhofer) microscope really seen it, and distinctly. Even in the red particles of human blood, I have seen a minute, round, accurately defined nucleus, which had a more yellowish and shining aspect than the transparent part around it. The existence of the nucleus can also be demonstrated by the action of acetic acid, though much less distinctly than in the case of frog's blood[‡]."

76. To me the appearances presented by the nucleus of the corpuscle in human blood, after the addition of acetic acid, were such as those represented in fig. 23: some of which, I think, are really sufficient to explain its usually biconcave form, and the difference in this respect between the blood-corpuscle of the Mammal and that of other Vertebrata.

77. I am very much inclined to believe, that in the many instances in which authors on "cells" have described and figured more than one nucleolus in a nucleus, there has been either an incipient division of the nucleus into discs, or the nucleus has consisted of two or more discs: the nucleoli of those authors having been the minute and highly refracting cavities or depressions in the discs[§]. If this has really been the case, it affords additional evidence, I think, that reproduction of cells by the process I have described—namely, division of the nucleus of a parent cell—is universal; so numerous have been the instances in question. I may refer to the figures given

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[†] Elements of Physiology, translated by Dr. William Baly, p. 146.

[‡] *L. c.*, pp. 100, 101.

[§] The observer is very apt not to perceive that a nucleus is composed of more than one disc, because of the refraction of light being very small at the part where the discs lie one against the other.

by Schwann[†], who examined nearly every animal tissue, and to those of Schleiden[‡], whose observations have been so extended on the cells of plants. I think, indeed, that many of the figures of Schwann afford evidence of the division in question having taken place. It is to be recognized in his delineations of the cells of cartilage[§], cellular tissue[‖], the middle coat of the aorta[¶], muscle[††], tendon[‡‡], the feather[§§], &c. The same remark is applicable to a figure given by Reichert of ciliated epithelium-cells[‖‖]. Dr. Henle found that in the layers of his "Pflasterepithelium" cells, the nucleus, very distinct in the lower cells, had almost disappeared in those situated at the upper part. From this observation, and from the presence of two nucleoli in some of the nuclei figured by this observer[¶¶], as well as from the nucleus becoming "more granular[†††]," I think it extremely probable that these cells also (including those of the epidermis) are reproduced by the process just referred to—division of the nucleus; additions being no doubt continually made at the lower part of the layer, by which cells previously there are pushed further out. Dr. Henle mentions that in the lowest of the cells of "Pflasterepithelium," the nucleus is "reddish yellow, and has a remote resemblance to blood-corpuscles[‡‡‡]." This is very interesting in connection with an observation recorded in my former paper on the Corpuscles of the Blood. I stated that epithelium-cells had often presented appearances which almost suggested the idea that these too were changed corpuscles of the blood: and that it was not easy to draw a line, by which the two could be distinguished, either in colour, form, or general appearance[§§§]. The cells here referred to were probably the "cylinder," or rather the subsequently "flimmerepithelium" cells of Henle[‖‖‖].

78. I showed on a former occasion that the chorion arises by a coalescence of minute cells[¶¶¶]; and we have since seen the thickening of this membrane to be effected by the same means[††††]. The cell which (in the first of my communications to the Society) I called the ovisac, appears to arise in the same manner, as well as the membrane *e* of my papers on the Embryo, for it really does appear, as I formerly suggested[‡‡‡‡], that the substance surrounding the germinal vesicle in the mammiferous ovum, usually called the yelk, may be termed a great "cytoblast."

[†] *L. c.*

[‡] *L. c.*

[§] *L. c.*, Tab. I. figs. 8, 9. Tab. III. fig. 1.

[‖] Ibid. Tab. III. figs. 6. 9.

[¶] Ibid. Tab. III. fig. 12.

[††] Ibid. Tab. III. fig. 13.

[‡‡] Ibid. Tab. III. fig. 11.

[§§] Ibid. Tab. II. fig. 11 *a*.

[‖‖] *L. c.*, Tab. I. fig. 4.

[¶¶] *L. c.*, Tab. I.

[†††] Ibid. p. 7.

[‡‡‡] *L. c.*, p. 6.

[§§§] *L. c.*, par. 49. Plate XXIX. figs. 11, 12.

[‖‖‖] See my Researches in Embryology, Third Series, *l. c.*, Plate XXVIII. fig. 251, which presents apparently more advanced stages of the objects delineated in the figures referred to in the preceding note.

[¶¶¶] Derived from corpuscles of the blood. Researches in Embryology, Third Series, *l. c.*, par. 369–373. On the Corpuscles of the Blood, *l. c.*, par. 20–26.

[††††] Supplementary Note to a paper entitled "Researches in Embryology. Third Series: A Contribution to the Physiology of Cells," in the present volume, p. 193.

[‡‡‡‡] Third Series, *l. c.*, par. 350. *Note.*

79. Now this mode of origin of cells of comparatively large size, may perhaps assist us in the consideration—how are the minuter ones produced? I formerly stated† that it was not easy to point out where the disc terminates, and the cell begins; and that I did not recollect to have observed any of the discoid objects in the transition state in question, in which there was not an appearance in the most superficial part denoting decomposition. I added, that so uniformly had this been met with that I was ready to suppose the formation of the cell-membrane to be connected with such decomposition, or perhaps dependent on it. From later observations, I am more and more disposed to think that this really is the case; and that exceedingly minute discs, into which the outer portion of a larger disc has been resolved, coalesce to form the membrane of the cell. Thus in fig. 54. the outer portion of discs such as those at α, seemed at β to have resolved itself into minuter discs, which at γ were more advanced, and at δ had coalesced to form the membrane of the corpuscle or blood-cell.

80. It will be seen from what I have in this memoir, and elsewhere, stated, that the disc ("nucleus" of authors) is the most primitive object we are acquainted with. It will also be perceived that the cavity or depression ("nucleolus") in the disc, is the situation of the future orifice, communicating with the exterior of the cell. The nucleus of the cell seems to be reproduced by the fissiparous mode.

81. The objects into which the nucleus of the mammiferous blood-corpuscle separates (fig. 23.), are no doubt the source from whence proceeds the substance for the origin and thickening of the chorion, and the formation of the muscular fibril‡.

82. The process by which the nucleus of the cell finally divides into several parts, seems to consist in the originally single and pellucid cavity or depression in the nucleus, gradually becoming finely granular (see the explanation of fig. 43.); and by degrees separating into several cavities. An idea of this change may perhaps be obtained from the condition of the nucleus in the blood-corpuscle ζ, fig. 45.

83. The nuclei which several observers have found lying among the fibres of various tissues, have been considered by them as the "remains of cells." This may have been the case; but so far from thinking, with those observers, that the nuclei in question were "destined to be absorbed," I am disposed to consider that they were the sources from which there would have arisen new cells. See, for instance, delineations by Schwann of nuclei lying among fibres from a feather (*l. c.*, Tab. II. fig. 13.). (And I may here take the opportunity of remarking, that I apprehend the fibres in

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† Third Series. Additional observations, par. 439. *Note.*

‡ See my Third Series on the Embryo, *l. c.*, and also the figure accompanying a Supplementary Note to that Third Series, in the present volume, p. 193; as well as my first paper on the Corpuscles of the Blood, *l. c.*

the more advanced of the objects in this figure, to have arisen from the coalescence of discs such as those represented in the object presenting an earlier state: a view which SCHWANN does not appear to have taken.)

84. I have observed, here and there, in blood taken from the liver in the fœtus of the Ox, large cells such as those represented in outline in fig. 31. (See the explanation of the Plates.) The nuclei of these cells presented a very remarkable appearance. They were composed of transparent discs, having, as viewed in the microscope, that peculiar yellow colour, which seems to characterize the corpuscle of the blood; and which when these corpuscles are accumulated, presents to the naked eye the well-known red. These discs, perhaps in some instances about twelve in number in each nucleus, were elliptical, and exhibited a cavity or depression. They were distinctly unconnected, though in contact, with one another; and seemed on the point of being separated. The figure represents one cell from which they were escaping.

85. Future observation must determine what these discs really are, I venture to believe it very possible that they represent a state of the corpuscles of the blood.

86. On a former occasion[†], I showed that the blood-corpuscles in the embryo are not formed, as supposed by some observers, out of granules of the yelk. The facts recorded in the foregoing memoir leave little doubt, I think, that these corpuscles,—not only in the embryo, but at all periods of life,—are descendants of the two cells constituting the foundation of the new being in the ovum. If so, it is not requisite to seek the origin of these corpuscles in the organized parenchymatous substance of the body, or in the globules of the chyle; "the only two sources," it has been said, in which it was possible for them to arise. Authors on "cells," regarding the liquor sanguinis as the "cytoblastema," appear inclined to consider the corpuscles of the blood as arising in it, independently of previously existing corpuscles.

87. EXPLANATION OF THE PLATES.

PLATE XVII.

Fig. 23. Man. Blood-corpuscles, after the addition of acetic acid. α. The nucleus consists of two adherent discs. β. The two discs have separated, and increased in size. γ. They exhibit symptoms of division. δ. The discs are four in number; but two of them remain attached. ε, ε. There exist three separate discs, with indications of a division of some of these discs. ζ. The number of discs visible is five. Three of the objects are in this state. η. The nucleus is indistinctly seen, from the surrounding discs and red colouring matter having been imperfectly dissolved.

[†] On the Corpuscles of the Blood, *l. c.*, par. 11.

Fig. 24. Ox (*Bos Taurus*, Linn.); embryo of $\frac{3}{4}$ths of an inch in length. Corpuscles of blood taken from the back part of the head. α. The nucleus consists in two instances of two, in another instance of three discs, which are in close approximation. β. The discs have separated, much increased in size, and assumed a cell-like appearance. γ. The corpuscle exhibits an orifice.

Fig. 25. Blood-corpuscles from the same embryo, after remaining twenty-four hours between two plates of glass. They had begun to collapse; a change which seems to commence by a falling in of that part of the membrane where the nucleus lies, and where an orifice in the membrane is in some states to be discerned.

Fig. 26. Blood-corpuscle from the liver of the same embryo. The nucleus seemed to consist of two portions.

Fig. 27. Blood-corpuscles from the liver of the same embryo, after the addition of acetic acid. The latter has made them globular. In all, the nucleus consists of two discs. In the lower one, large discs or incipient cells are represented surrounding the nucleus.

Fig. 28. Ox (*Bos Taurus*, Linn.); embryo of about one inch in length. Outline of corpuscles in blood taken from the back part of the head. These were not very flat, especially the smaller ones, which were much more numerous than the large. α, α. The corpuscle presents an orifice. β. A nucleus is visible, consisting of two closely adherent discs.

Fig. 29. Blood-corpuscles, chiefly in outline, from the same part of the same embryo, after the addition of acetic acid; which has rendered most of them spherical in form. After some time, they became shrivelled in appearance. α. Ruptured corpuscle. β. Corpuscle from which a globular object (presenting on one side the membrane of a minute cell?) is escaping. γ. Object nearly resembling a mature blood-corpuscle, surrounded at a little distance by a membrane. δ. A similar object on its edge, but without a surrounding membrane. It presents an orifice on one of its broad surfaces.

Fig. 30. Ox (*Bos Taurus*, Linn.); embryo of $1\frac{1}{4}$ inch in length. Outline of blood-corpuscles from the liver, after the addition of acetic acid. α. Corpuscle containing two globules, composed of discs. β. Corpuscle discharging a globule of the same kind; the membrane of a minute cell rising from this globule. γ. A similar compound globule, probably recently discharged from a corpuscle, and now eccentric in a minuter cell.

Fig. 31. Ox (*Bos Taurus*, Linn.); embryo of $1\frac{3}{4}$ inch in length. Outline of corpuscles in blood from the back part of the head, after the addition of a very minute quantity of acetic acid. In the larger ones, the nucleus

became well circumscribed through this addition. These corpuscles exhibited a pellucid orifice.

Fig. 32. Outline of a corpuscle from the same embryo; the nucleus consisting of a single disc.

Fig. 33. Sheep (*Ovis aries*, Linn.); embryo of 2½ inches in length. Blood-corpuscles after the addition of acetic acid.

Fig. 34. Blood-corpuscles from the liver of the Ox-embryo from which figs. 31 and 32 were taken. Acetic acid had been added. *α*. Corpuscles resembling those in fig. 27. *β*, *β*. Escaped nuclei; each consisting of two discs. *γ*, *γ*. Corpuscles resembling those in fig. 33; but their compound nuclei separating into discs. *δ*. Corpuscle exhibiting an orifice in its membrane; the sides of the orifice presenting a finely granular substance. *ε*. Corpuscle containing three compound globules similar to those in fig. 30; but much more minute. Several of the corpuscles in this figure (fig. 34.) were seen to be filled with enlarged discs or incipient cells. A few of these have been represented in outline.

Fig. 35. Outline of large cells found with those in the preceding figure. Their membranes appeared shrivelled. These cells were filled with altered discs, and more or less incipient cells. Each of their nuclei consisted of many discs, of a deep yellow (reddish) colour. (Such cells were found in blood from another embryo of the Ox, measuring in length 1¼ inch.)

PLATE XVIII.

Fig. 36. Sparrow (*Fringilla domestica*, Linn.). Blood-corpuscles, chiefly in outline. It will be observed that two of these are round. Like the rest, however, these two were flattened. Round ones were seen only here and there. *α*. A group of young corpuscles of the blood. Their colour was the same as that of the other corpuscles in this figure; but they were less flattened. The pellucid space represented in some of these objects (*α*), indicates the situation of the future nucleus (see the explanation of fig. 43.). *β*. A blood-corpuscle in which there were observed discs or young cells around the nucleus. The nucleus has not been figured.

Fig. 37. Sparrow (*Fringilla domestica*, Linn.). Blood-corpuscles with their nuclei —both in outline—as seen after the addition of a *minute* quantity of acetic acid. The corpuscles on the left hand, in the figure, had undergone only a partial change in their form from the acetic acid; while those on the right (lying in another part of the field of view) had become globular from this acid. *α*, *α*, *α*. The nucleus has changed its position;

having become in two instances oblique, in another instance situated on one side. *β*. It is dividing into two parts. *γ*. This division is complete. *δ*. From the direction of the nucleus, only one of its extremities is seen. The corpuscle in this instance had lost its flattened form, but not yet become globular.

Fig. 38. Sparrow (*Fringilla domestica*, Linn.). Nuclei of blood-corpuscles, after the removal of the surrounding substance by acetic acid.

Fig. 39. Sparrow (*Fringilla domestica*. Linn.). Two blood-corpuscles filled with discs, or young corpuscles; and two young corpuscles in nearly the same state, but no longer contained within a parent corpuscle (cell). Acetic acid had been added in *minute* quantity.

Fig. 40. Common Fowl (*Phasianus Gallus*, Linn.) in an egg incubated eighty hours. Outline of blood-corpuscles. An orifice is visible in some, and not in others.

Fig. 41. Blood-corpuscles from the same egg, after the addition of acetic acid. They are represented partly in outline. *α*. The nucleus consists of two discs. *β*. It is composed of several. *γ*. Globular corpuscle filled with young corpuscles.

Fig. 42. Common Fowl (*Phasianus Gallus*, Linn.), in an egg incubated eighty-five hours. Outline of blood-corpuscles. (Discs were indistinctly visible in the interior, even before the addition of any acetic acid.)

Fig. 43. From the same egg. Outline of blood-corpuscles, after the addition of acetic acid. *α*. The corpuscle has an elongated orifice. *β*. The corpuscle is filled with minute cells. Its finely granular nucleus has a pellucid cavity, communicating with the exterior of the corpuscle (compare this object with the germinal vesicle, Phil. Trans. 1840, Part II. Plate XXII. fig. 159.). This orifice is originally larger. It becomes reduced in size with the appearance of the finely granular substance: the latter preceding the formation of the discs, into which the nucleus is resolved. *γ*. The nucleus consists of two discs. *δ*. The nucleus is composed of several discs.

Fig. 44. Common Fowl (*Phasianus Gallus*, Linn.), in an egg incubated ninety-two hours. Outline of corpuscles of the blood.

Fig. 45. From the same egg. Blood-corpuscles, chiefly in outline, after the addition of acetic acid. These were globular, or nearly so, excepting two, which were elliptical. The latter form was not frequent after acetic acid had been added. All the corpuscles in this figure were seen to be filled with discs or incipient cells. *α*. Corpuscle with a large orifice. *β*. The nucleus finely granular, with a minute cavity (see the description of fig. 43.). *γ*. The nucleus as in *β*; concentric layers of discs or incipient cells around it. *δ*. The orifice elongated, with an accumulation of finely granular substance beneath it, having a minute central and pellucid cavity (see the description of fig. 43.). ε. The nucleus consists of two discs. ζ. One of the two discs of which the nucleus is composed seems preparing to divide into minuter discs. η. The nucleus consists of three discs. θ. The nucleus is composed of several discs, surrounding a pellucid cavity. ι. The nucleus consists of many discs. κ. Globular corpuscle filled with discs, apparently young corpuscles.

Fig. 46. Common Fowl (*Phasianus Gallus*, Linn.), in an egg incubated 166 hours. Outline of corpuscles of the blood.

Fig. 47. From the same egg. Two blood-corpuscles after the addition of acetic acid. The drawings of the discs, or incipient cells, around the nucleus in these are more finished than those of the corresponding parts in many of the other figures. α. The nucleus consists of two discs. β. It is composed of three objects, each of which seems to be dividing into two discs.

Fig. 48. Turtle. Blood-corpuscles after the addition of acetic acid; some of them in outline. α. The nucleus dividing into two discs. β, β. The nucleus consists of two closely adherent discs. γ. The nucleus is composed of two discs; the one lying across the other.

Fig. 49. Turtle. Blood-corpuscles after the addition of acetic acid; two of them in outline. α. The nucleus is a single disc. In one of these corpuscles there are represented discs or incipient cells. β. Corpuscle beginning to collapse.

Fig. 50. Frog (*Rana temporaria*, Linn.). Blood-corpuscles after the addition of acetic acid; one of them in outline only. α. The nucleus is a single disc. β. The nucleus is dividing into two discs. γ. The nucleus consists of two distinct discs. δ. The nucleus is dividing into three discs. ε. The corpuscle contains many incipient cells. (The nucleus has not been represented in ε.)

Fig. 51. Thornback (*Raia clavata*, Linn.). Blood-corpuscles, after the addition of acetic acid; one of them in outline. Some remained elliptical. α. The nucleus is a single disc. β. The nucleus is dividing into two discs. γ. The nucleus consists of two distinct discs. δ. Minute corpuscle filled with minuter cells; its nucleus consisting of two closely adherent discs. ε. Corpuscle, the nucleus of which consists of two compound globules. Compare with fig. 30 α, and fig. 34 ε.

Fig. 52. Skate (*Raia batis*, Linn.). Blood-corpuscles, after the addition of acetic acid. The larger ones are in outline. (The greater number of the corpuscles seen were of the second and third size.) The corpuscles did not become globular on the addition of acetic acid. α. The nucleus is a single disc, but it is beginning to divide into two. At β this division

has proceeded further. At γ, γ the nucleus is dividing into three parts. In one of the corpuscles γ, are seen, in outline, minute cells. δ, δ. The nucleus consists, in one corpuscle of two, and in another of three, distinct discs.

Fig. 53. Cod (*Gadus Morrhua*, Linn.). Blood-corpuscles after the addition of a *minute* quantity of acetic acid. They are represented for the most part in outline. The sizes and forms most frequent were such as those of the larger corpuscles on the left side in the figure. α. Discs or cell-like objects are contained within the corpuscle, around the nucleus. This was seen to be the case in corpuscles generally throughout the field of view. The nucleus consisted in general of two or more discs. β. Globular corpuscle filled with discs, apparently young blood-corpuscles.

Fig. 54. Cod (*Gadus Morrhua*, Linn.). Blood-corpuscles after the addition of a *minute* quantity of acetic acid. Some of them are in outline only. The objects α, β, γ, δ appeared to be young blood-corpuscles; of which α represents the least advanced, and δ the most forward state (par. 79.). Discs or young cells were seen around the nucleus in all the larger corpuscles of this figure; and indeed in the majority of such of the corpuscles from this individual, as were minutely examined. They were visible in a great number of instances without any addition having been made. The discs in the corpuscle ζ are larger than those in ε; while the nucleus is smaller. At η, the crenate circle represents the outline of a layer of discs or young cells, which surrounded the nucleus. The space external to this layer, seemed to be occupied by red colouring matter.

PLATE XIX.

Fig. 55. Frog (*Rana temporaria*, Linn.). Nuclei of blood-corpuscles, and other objects, observed in the blood, after the addition of acetic acid. α Resembles the compound globules in figs. 30, 33, ε of fig. 34, and ε of fig. 51.

Fig. 56. Nuclei of blood-corpuscles (and other objects?), observed in blood of the same animal, several days dead. These nuclei were no longer contained in cells.

Fig. 57. Oyster (*Ostrea edulis*, Linn.). Objects found in the blood. α. Cell, the nucleus of which consists of two closely adherent discs. Compare this cell with many of the blood-corpuscles from vertebrated animals in Plates XVII. and XVIII. β, β. Globules composed of three or more discs. γ. Globules circumscribed by a membrane-like lamina, and composed of discs resembling those in figs. 30, 33, and ε of fig. 34. from

the Mammal, and ε of fig. 51. from the Fish. δ. Globules composed of discs surrounding a pellucid cavity. Compare with the nucleus of θ in fig. 45. from the Bird. ε, ε, ε. Cup-like objects composed of discs; one of them in outline. ζ. One of the same objects apparently in a more incipient state. Compare the objects ε and ζ with those in fig. 58. from the Turtle.

Fig. 58. Turtle. Cup-like objects observed in the blood, after the addition of acetic acid. Five of them are in outline. Compare these objects with ε of fig. 57. from the Oyster.

Fig. 59. Ox (*Bos Taurus*, Linn.). Embryo of about one inch in length. Globules and other objects from the brain. They are composed of discs. Compare these objects with some of the nuclei of blood-corpuscles in Plates I. and II. Acetic acid had been added.

Fig. 60. Objects from the Brain of another embryo of the same animal, measuring $1\frac{3}{4}$ inch in length, after the addition of acetic acid. Previously such globules in many instances seemed to be surrounded by the membrane of a minute cell. Compare as in the description of fig. 59.

Fig. 61. Lobster (*Cancer marinus*, Linn.). Corpuscles (partly in outline) observed in the blood, after the addition,—α. of alcohol,—β. of acetic acid.

Fig. 62. Leech (*Hirudo medicinalis*, Linn.). Corpuscles of the blood. Some were observed larger than any of those represented in the figure.

XVII. *On the Corpuscles of the Blood.—Part III.* *By* MARTIN BARRY, *M.D.*, *F.R.SS. L.* and *E.*

Received June 17,—Read June 17, 1841.

NOTWITHSTANDING the great length of time during which the blood has been the subject of physiological research, an eminent anatomist, so late as the year 1838, remarks, that "we have no clear conception of the mode in which the floating corpuscles of the blood conduce to nourishment[†]." That Professor WEBER was not mistaken in coming to such a conclusion, I think will be admitted by every one who takes the pains to consult the records of discovery in this most interesting field of observation.

I am not aware that, since the period just mentioned, any additional facts have been published, relating to "the mode in which the floating corpuscles of the blood conduce to nourishment," unless my own communications, already presented to the Society[‡], are to be so regarded,—those communications having reference to the mode of propagation of the floating blood-corpuscle, and to its conversion into two or three kinds of tissues.

The object of the present memoir is to bring together a large number of observations, made by myself, showing that every structure I have examined arises out of corpuscles having the same appearance as corpuscles of the blood. I may here mention, that the tissues submitted to actual observation, with the result just mentioned, will be found to include the cellular, nervous, and muscular; besides cartilage, the coats of blood-vessels, several membranes, the tables, cells, and cylinders of the epithelium, the pigmentum nigrum, the ciliary processes, the crystalline lens itself, and even the spermatozoon and the ovum. And among the vast number of observations made, I have not been able, with the greatest care, to detect a single fact inconsistent with the conclusion above announced. If that conclusion—which regards the *formation* of the tissues—be correct, it may, I think, assist us in considering "the mode in which the floating corpuscles of the blood conduce to nourishment" *during life*.

For the detail of these observations, I shall rely principally upon the drawings, and the minute explanation of them separately given. The perusal of that explanation will, I conceive, be necessary for the understanding of some general remarks I shall have to offer: and I can scarcely expect the reader to admit the conclusions drawn, until he is in possession of the unequivocal evidence, to be derived in no other way than by a close examination of the Plates, in connection with the explanation just referred to.

[†] E. H. WEBER, in MÜLLER'S Archiv, 1838, p. 463.

[‡] On the Corpuscles of the Blood. Philosophical Transactions, 1840, Part II. p. 595: and Part II. on the same subject, in the present volume, p. 201.

I may here mention, that it is not my object in this memoir, to trace the tissues investigated into a perfectly formed state; but simply to present such of their earliest stages, as show them to be derived from objects having the same appearance as corpuscles of the blood. In so doing, I shall have to mention a variety of facts, which, though met with incidentally, and recorded without remark, may not be considered destitute of physiological interest.

88. It is important that any one disposed to repeat the following observations, should, before entering upon them, carefully notice the colour,—the transparent yellow colour,—of the corpuscles of the blood, viewed singly, with a high magnifying power (as, for example, the corpuscles in blood obtained by a puncture of the finger); so that when the same colour is met with elsewhere, he may recognize it. The yellow of the magnified corpuscle as thus singly viewed, is obviously that which gives to the mass of blood—seen with the naked eye, and by reflected light—its well-known red. The reader will bear this in mind, when colour is spoken of in the following memoir.

89. Some of the observations I am about to communicate, will be found at variance with those of other investigators in general anatomy, not excepting even the most recent. I have not room, within the limits of a paper, to introduce the opinions of the authors referred to.

90. On former occasions, I have mentioned a certain minute structure, under the denomination *disc*. As the same term will be constantly employed in this memoir, it is better, once for all, to define it, as a flat, elliptical or circular body; usually having a concavity in the middle of the flat surface (fig. 141 δ, δ, ε.). Frequently, however, these minute bodies lose their elliptical or circular form, and assume, as if by pressure, a polyhedral shape; and, in certain states, the concavity becomes an orifice. There are also conditions in which a minute projection is presented at this part. Numerous examples of discs are to be found in almost every figure which accompanies the paper.

91. The *disc* seems in many instances to correspond to the "cytoblast" of SCHLEIDEN; though his description of the "cytoblast" differs in some material points from the definition I have given of the disc†: and our experience of the destination of these objects is no less different. In the proper place it will be shown that the disc has been described by some as a peculiar object, found in two or three kinds of globules.

92. By *division into discs*, an expression frequently made use of in this paper, I do not mean simple separation. For, from the analogy which seems to exist between the mode of propagation of the blood-corpuscle, and that of the cells which are the immediate successors of the germinal vesicle in the ovum, there cannot be a doubt

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† See Third Series on Embryology, Philosophical Transactions, 1840, Part II. pars. 385, 425.

but that, in all instances, and whatever the minuteness of the object, the division in question takes place by a similar process,—a process which we found to be elaborate in the extreme.

93. The expression, *having the same appearance as the corpuscles of the blood*, is constantly made use of in the following pages; though most of the corpuscles to which it is applied would have been at once denominated corpuscles of the blood, but for a reason given in the concluding portion of the memoir (par. 196.).

94. Besides the substances above mentioned, I have examined the pus and mucus globules, which I shall first describe.

The Globules of Pus derived from Corpuscles of the Blood:—Mucus-globules compared with them.

95. "The nucleus of the mucus-corpuscle," says SCHWANN, "has the peculiarity, discovered by GÜTERBOCK, of becoming separated into two or three corpuscles of minuter size by acetic acid; while the surrounding part is gradually dissolved by this reagent. VOGEL supposes this property to belong only to pus-corpuscles, and to the corpuscles of unhealthy mucus. HENLE, however, informs me," continues SCHWANN, "that the same peculiarity *** is found in the true mucus-corpuscles, present in healthy mucus[†]." Respecting pus-corpuscles, SCHWANN remarks, "They share with them [corpuscles of mucus] the peculiar relation towards acetic acid[‡]."

96. My own observations on this subject are the following. In Plate XX. fig. 64 β. are pus-globules, to which no addition whatever had been made; and fig. 63 ζ presents one of these globules, as viewed after the addition of dilute spirit. Now as the objects in both figures exhibit the division of the "nucleus," just spoken of, without the addition of acetic acid, I am compelled to form an opinion opposed to that of the authors just referred to, and to maintain that in the pus-globule acetic acid is not required to produce such division.

97. But facts recorded in several of my former memoirs appear to have been sufficient for showing that neither acetic acid nor any other foreign substance is required to produce division of what has been called the nucleus of the pus-globule; such division being part of the process by which cells are reproduced, and apparently universal in its operation. The present memoir, also, will be found full of facts, showing that this really is the case.

98. As to the mode of origin of the objects in question, SCHWANN remarks, "The pus-corpuscles are thus probably peculiar cells, forming in the pus-serum, that is in the cytoblastema, which in inflammation exudes in greater quantity and unusual mixture, in the same manner as the mucus-corpuscles form in mucus, and as all cells

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[†] Mikroskopische Untersuchungen über die Uebereinstimmung in der Struktur und dem Wachsthum der Thiere und Pflanzen, 1839, pp. 77, 78.

[‡] *L. c.*, pp. 78, 79.

form in their cytoblastema. Their formation appears, according to the observations of H. Wood, to take place first at the surface of the granulations[†]."

99. The latest published view I am acquainted with, as to the mode of origin of pus and mucus-globules, is that of Dr. Mandl[‡], with whom it appears to have been a principal object to point out the relation between these globules and the blood. This author considers the globules of pus and mucus as identical; but that they can by no means be regarded as altered corpuscles of the blood; for he supposes that the latter, by contact with pus, are dissolved. As to the nature of the globules of pus and mucus, he states them to be "fibrinous globules," such as those which he was the first to describe. He thinks that the blood passes through the walls of its vessels, with all its elements except the corpuscles, which cannot be thus transuded; and that the liquor sanguinis which contains the fibrin in solution, thus placed out of the circulation, gives origin to a coagulation of the fibrin; and, as the serum itself transudes only drop by drop, it is in drops that the fibrin coagulates; thus forming the corpuscles known by the name of globules of pus, mucus, &c.[§].

100. The following are my own observations on this subject; altogether differing, it will be seen, from those just referred to.

101. Fig. 63. represents objects seen in fluid of a blood-red colour[||], from an abscess in the human subject, to which fluid no addition had been made. The field of view was occupied by myriads of young blood-corpuscles, among which were seen all the states represented in this figure. Proceeding through the figure in the order in which the objects are alphabetically lettered, we find the corpuscle of the blood—known to be discoid in its form—gradually assuming an orange shape, and finally becoming globular. Then, however, it is not the entire corpuscle, but the enlarged nucleus of the same. In the situation of the depression in the original blood-disc, there is now seen a pellucid orifice (α). This orifice appears to be at first round. It either continues of this form,—or it elongates,—or becomes triangular (β). A reddish substance, stretching across the orifice, divides it, when elongated into two, and when triangular into three orifices (γ). The intervening substance seems to become more consistent (δ); many minuter orifices come into view,—apparently the pellucid centres of as many discs, the outlines of which discs are hidden by red colouring matter (ε); and, finally, on the extreme right in the figure, we have the formed pus-globule (ζ).

102. From this observation, with others, I am induced to believe that the pus-globule is the altered nucleus of a corpuscle of the blood.

103. The microscopical appearance of pus-globules is pretty generally known. Dr. Vogel gave me drawings of them, accompanied by a description, from his own observations, in 1837; and I have not seen them more accurately delineated or described by any subsequent observer. "They are uneven at the surface," says Dr.

[†] Schwann, *l. c.*, p. 79. [‡] Gazette Médicale de Paris, 4 Juillet, 1840. [§] *L. c.*, p. 419.

[||] Furnished by my friend William Marten Cooke, M.B.

Vogel, "being covered with minute granules; and with the addition of acetic acid they undergo a peculiar change. There then appear simple granules, generally two or three in each pus-globule (rarely one only or four), which are oval or roundish, having for the most part a somewhat projecting margin, giving them almost a basin-shaped appearance. They are surrounded by a delicate halo or covering, which, with the continued influence of acetic acid, entirely disappears, so that the isolated granules remain alone[†]." The numerous observations of **Gulliver** on pus, are deserving of attention[‡]. This author, however, describes the "molecules" (the term he uses) as spherical, and as "*centrically* inclosed in an external part;" and he does not mention the depression which each of these "molecules" presents.

104. My own views of the pus-globule are in some respects peculiar. The formation of this object out of the nucleus of the blood-corpuscle, appears to me to be referable to the same process, essentially, as that by means of which the germinal spot comes to fill the germinal vesicle, in the ovum. This process having been particularly described in a former memoir[§], I need not refer to it in detail here. Its effects are seen progressing in fig. 63, and they have been rendered more obvious by acetic acid, and by alcohol in fig. 64. In the latter figure, an originally single nucleus consists, for the most part of two, in one instance of three, layers of discs or incipient cells; the highly refracting (and probably most essential) portion being, as in all other nuclei, the part formed last.—That the term *nucleus* is here not inappropriate, as applied to the pus-globule, will I presume be admitted, should others, before adding any foreign substance, find the pus-globule to be contained within a cell, as frequently as I have noticed this to be the case. If so, however, the highly refracting discs form together, not the "nucleus," as they have been called, but the nucleolus.—It will be seen that I differ from previous observers, in considering the *outer* portion of the pus-globule to be composed of discs or incipient cells. But this is only one of many differences between the observations here recorded, and those of other investigators.

105. I have already stated that the object called by me the *disc*, had in several instances been described by some as a peculiar structure found in two or three kinds of globules. The term *disc* is synonymous with the "basin-shaped granules" of **Vogel**, and the "spherical molecules" of **Gulliver**, seen in the globule of pus; the same object having been observed also by **Güterbock**, **Henle**, and others who have investigated the structure of the pus-globule.

106. The condition of portions of a capillary network, which I have found in pus, —a minute fragment of which, in outline, is represented in fig. 65,—confirms the

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[†] Dr. Vogel has since published a work entitled "Physiologisch-pathologische Untersuchungen über Eiter, Eiterung, &c." Erlangen, 1838, which, however, I have not seen.

[‡] London Medical Gazette, 1839, 1840. Medico-Chirurgical Transactions, 1840.

[§] Researches in Embryology: Third Series. Philosophical Transactions, 1840, Part II. par. 385.

idea recorded in my first communication on the corpuscles of the blood[†], namely, that the appearance of these corpuscles in inflammation is the same as that which they present in vital turgescence of the vessels; an appearance which seems to be referable to changes effected by a process of the same kind as that above referred to. In such portions of capillary network, the corpuscles are found to have assumed the same colour as the pus-globules. The fragment in question contained what seemed to be a pus-globule at a certain part; and very possibly the other corpuscles in this vessel had been destined to furnish globules of pus. The occurrence, however, of pus-globules in the blood-vessels, I am aware is by no means new.

107. "According to HENLE," says SCHWANN, "the corpuscles of pus are not distinguishable from those of mucus[‡]." Dr. MANDL's opinion, that these objects are identical, has been already mentioned. If then pus and mucus-globules are "identical," or "not distinguishable," their source is not likely to be very different: and pus-globules we have just seen to be derived from corpuscles of the blood. I would also compare figs. 68 to 71. (mucus), with figs. 63 and 64. (pus) in this memoir, as well as with fig. 23. (blood-corpuscles) in my last paper[§]. See also figs. 72 and 73. in the present communication. The blackish mucus from which these last were taken, presented, not merely corpuscles having the same appearance as altered blood-corpuscles, but such as resembled young corpuscles of the blood themselves, of the characteristic colour, and in an unaltered state.

108. Whether the highly refracting globules in the cells fig. 103. were those of fat, I do not know; but their appearance suggested the idea that this was the case; and the cells containing these globules were certainly altered corpuscles of the blood. For a particular description of these cells, I refer to the explanation of the figures. It may, however, be added here, that each of the globules resembling fat seemed to occupy the *central* part of what had previously been discs.

109. There are but few of the figures accompanying this memoir, which do not directly or indirectly confirm the observations recorded in my last. Among those affording direct confirmation of the same, may be mentioned figs. 75, 76, 77, 78, 79, 80, 81, 82, 83, 84. Some of the blood-corpuscles in these figures exhibit discs, existing both within and around the nucleus of the blood-corpuscle while in circulation. Others (figs. 67 *α*. 76. 78.) seem to represent conditions of the "lymph-globules," or "corpuscles of the second form" of authors.

110. The only views I am acquainted with, regarding the place which blood-corpuscles should be considered to occupy as "cells," are those of SCHWANN, and VALENTIN. The former considers this corpuscle as a nucleated cell; while the latter

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[†] *L. c.*, par. 48. fig. 20.

[‡] *L. c.*, p. 80.

[§] On the Corpuscles of the Blood, Part II. *l. c.*, p. 201.

maintains that it is a nucleus,—the object usually termed the nucleus, being really the nucleolus. From my own observations, it appears that, paradoxical as it may seem, both these views admit of being established. The fact is, that at an early period the corpuscle of the blood is a mere disc, having a cavity or depression representing the "nucleolus." At this period the corpuscle may be called a nucleus; though it does not seem desirable to use this term, before the formation of the cell. Subsequently, the outer portion of the corpuscle or disc becomes transformed into minuter discs, which coalesce to form a membrane; and the inner portion is now the nucleus, the entire corpuscle being a cell.

111. At α of fig. 144. is a corpuscle resembling a young corpuscle of the blood, in which the central part was red, and the outer part pale. At α, fig. 95, is a blood-corpuscle, the discs in the altered nucleus of which, generally speaking, had a deeper red, the nearer they were to the centre of the nucleus. These may serve as examples, showing that there is a continual re-appearance of red colouring matter, and that it comes into view around the orifice in the nucleus.

Epithelium-tables, cells, and cylinders compared with Corpuscles of the Blood.

112. On examining the tail in a great number of Tadpoles,—the larva of the large Toad found in Jersey,—these Tadpoles measuring from $4'''$ to $6'''$ (Paris lines) in length, I found the central part of the epithelium-tables to present an appearance so varied, that it would have been vain to expect that, by figuring those of any one part, an idea could be given of their general appearance. Nor can I hope to have yet done so; but it seemed desirable to sketch a few of the states noticed, without regarding the relations of the tables to one another, and without confining myself, in the delineation, to the same individual.

113. Before referring more particularly to these, I will just express my surprise at its having been possible for any one to examine the tail of a single minute Tadpole, without recognizing in its epithelium, corpuscles having the same appearance as corpuscles of the blood. And I see no way of reconciling the acuteness of observers with the absence of this recognition, except by supposing the Tadpoles examined to have attained a far greater size than those examined by myself—measuring chiefly from $4'''$ to $5'''$. In those of the lengths now mentioned, I find it impossible to discern an essential difference in appearance between the objects entering into the formation of the edge of the tail, and blood-corpuscles circulating in this larva (par. 196.). The comparison is very easy, if made after the corpuscles are at rest within their vessels. It frequently happens too, that the placing of a piece of glass or mica upon the tail, lacerates the edge, and separates epithelium-tables from it (fig. 86. α, β.); when it is seen that these tables, in their form, size, colour, and internal state, have the same appearance as the blood-corpuscles which were circulating just before, in the same field of view.

114. The nucleus in some of the epithelium-tables fig. 86, bore a curious resem-

blance to certain states of the germinal vesicle figured in one of my former papers[†]. Other conditions of the nucleus in some of the same epithelium-tables, equally resemble the appearance of the discs or incipient cells succeeding that vesicle in the ovum[‡]: and in fig. 88. we have remarkable evidence of the appearances presented by the contents of the ovum, and those of the epithelium-tables, being both referable to the operation of the same process. This remark applies equally to blood-corpuscles, apparently destined to enter into the formation of the epithelium, in fig. 95.

115. The resemblance between corpuscles of the epithelium, and those of the blood, is not confined to the part we have been considering. All the epithelium-cells which have fallen under my notice present it more or less decidedly. Even those collected from the surface of the tongue (fig. 92.), while they exhibit the greatest irregularity in size and form, and considerable variety in the appearance of the interior, present the same sort of discs, and the same division into minuter discs; many of them being also tinged with the same red colouring matter as is perpetuated or reappears in the discs of other parts, more closely resembling corpuscles of the blood. The nucleus also of the epithelium-cell from the tongue, is composed of discs; and I have seen it remarkably tinged with red. Among the cells from a furred tongue, there were seen heaps of discs of a blood-red colour. The membrane of the epithelium-cell—where a cell exists, as in fig. 92.—is obviously formed by the same coalescence of discs, as that which we shall find to give origin to other membranes, —for instance, to the membrane of the ovisac, figs. 170, 171, 172, *h*.

116. The formation of what have been denominated epithelium-cylinders, I have not had the opportunity of particularly following; but may offer a few incidental observations. In fig. 94 *a*. is the outline of a cell which was red throughout, and filled with young epithelium-cells. The latter presented traces of division into objects still more minute; and this division at one part had really taken place. Traces of division were observed also in the objects figs. 95. 99. and 100; the blood-red colour of many of which, passed at one extremity nearly into black. Should these have been, as I believe they were, incipient epithelium-cylinders, the observation, so far from having realized the following conjecture of Professor VALENTIN, will stand in direct opposition to it. "It appears," says he, "judging at least from the nuclei, as though cilia-cylinders arose through the coalescence of two adjacent cells, and the disappearance of the partitions. There are often seen, at least, in one and the same cylinder, two nuclei, one on the other, or in part covering one another[§]." Were not the two nuclei, seen by VALENTIN, produced—like those in the figures, last referred to—by division of a previously single nucleus? If so, it would seem that cilia-cylinders arise, not by coalescence, but by division, like some of the Vorticellæ; which they resemble also in the position of the cilia.

[†] Compare with *c*, figs. 159, 160, 162, 169, in my Third Series on Embryology. Philosophical Transactions, 1840, Part II.

[‡] Compare with fig. 195 in my Third Series on Embryology, *l. c.*

[§] MÜLLER's Archiv, 1840, Heft II. p. 205. *Note.*

The Elements of the Pigmentum nigrum, and those of the Ciliary Processes, compared with Corpuscles of the Blood.

117. The general appearance of black pigment, as seen, in a formed state, in the choroid coat of the eye, is well known. And that variety of this substance met with in the tail of the Tadpole, has been accurately represented by Professor Schwann, in a certain stage[†]. As to the mode of origin, however, of this substance, in either of the localities just mentioned, I am not aware that we possess any published information: a remark equally applicable to the blackish substance found in mucus from the air-passages. Perhaps the following observations, therefore, may be useful.

118. In Tadpoles of $4\frac{1}{2}'''$ to $5'''$, I find the blood-corpuscles to contain, situated on the nucleus, certain red globules (fig. 75. α.), appearing to transform themselves into discs (β) of the same red colour. Now in the epithelium-tables above mentioned, as so much resembling the blood-corpuscle, the peripheral part is composed of red discs. The red discs of several tables are necessarily in contact. They coalesce, and present the appearance delineated in fig. 89. Each line of discs in this figure, it will be seen, is made up of those derived from two adjacent tables. These discs, quite red in the figure now referred to, subsequently divide into extremely minute, blackish objects, which adhere together, and form partitions between the central portions of the tables. In a state more advanced, it is not easy to discern this partition-like appearance, nor to connect the very irregular forms into which the partitions are distorted, with their original figures of six sides. At γ in the figure last mentioned, is a stage more advanced than that at β; but the objects were still seen to be composed of discs. They also presented a trace of the partition-like appearance, and were still red. In fig. 91, are stages of these objects yet more advanced (but from another part), and apparently corresponding to those figured by Schwann from the tail of the Tadpole. In the latter stages they are known under the name of pigment ramifications,—of which I think the observations now detailed, may assist to show the mode of origin.

119. The large object connected with the pigment ramifications (figs. 90, 91.) appears to be a centre for the reproduction of epithelium-tables; for those in fig. 88. are corresponding objects, in which this reproduction is very obvious—the pellucid, germinal vesicle-like nucleus on one side of the object figs. 90 and 91, being, more particularly, the centre from which the reproduction proceeds.

120. But one of the figures just referred to (fig. 91.) was taken from the pigment of the eye; which seems to be produced in a manner precisely such as that just described, as giving origin to similar appearances in the tail. This will be obvious, I think, if the object on the right hand in fig. 93. (eye) be compared with fig. 89. (tail). And each of these presents a centre for the origin of new substance (the peripheral discs), like the centres just referred to. (Fig. 93. will be found fully described in the

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[†] *L. c.*, Tab. II. figs. 8 and 9.

explanation of the Plates; with the mode of origin of the pigment in the choroid. The discs of the bright red δ and ε, in this figure, undergo division, and are given off, to enter into the formation of the darker and blackish ζ. It appears that what is seen of ζ in the figure, had been formed by portions previously given off in this manner. So that here, in the pigment of the eye also, we find centres (δ. ε.) for the origin of new substance). It is important to add, that all the objects now mentioned, had the appearance of altered corpuscles of the blood.

121. The black substance found in mucus from the air-passages, arises in a manner somewhat similar; presenting itself at the outer part of corpuscles quite as red as corpuscles of the blood. See fig. 72.

122. Portions of ciliary processes, as seen in the eye of a Tadpole of $5\frac{1}{2}'''$, are represented in fig. 101. They are in outline only; for the parts composing them, from their colour, form, size, and general appearance, so much resembled slightly altered blood-corpuscles, that it did not appear requisite to make elaborate drawings of them. It is, besides, extremely easy to repeat, and therefore to confirm, this observation, or show it to have been erroneous.

The Primitive Discs exhibit an inherent contractile power.

123. This was manifested by the elongated discs of the epithelium-cylinder fig. 98. α, β; and by the isolated disc, two appearances of which are represented at δ in the same figure. This isolated disc was observed for a considerable time to change its form and place. Some of the discs composing the paler part of the cylinder α, β, were, for about twenty minutes, seen to be in motion; and there was thus produced a very slow revolution of the entire object on its axis, in the direction of the arrow. (In connection with this subject, it may be mentioned, that the object in fig. 139 which is more finished in delineation than the rest, and constituted the centre of the forming crystalline, on being viewed repeatedly for a considerable time, was found to vary in its appearance; a phenomenon which seemed to arise from the discs changing their position. This object, as will be found stated elsewhere (par. 181.), had all the redness of a corpuscle of the blood.)

The Nuclei of Blood-corpuscles furnish themselves with Cilia, revolve, and perform Locomotion.

124. Ciliated corpuscles are seen in figs. 105 and 104. Those in the first of these two figures were observed in the blood of a rabbit, taken from vessels in the immediate neighbourhood of a Graafian vesicle, which, from its size and vascularity, had evidently been destined to expel an ovum. The corpuscles in the latter figure were noticed in a substance from the eye of a fœtal calf of $5\frac{1}{4}$ inches, more particularly described in the explanation of the Plates. The rabbit had been killed eighteen

hours; and two days had elapsed after the fœtal calf had been taken from the body of its mother, before I made the observation now recorded.

125. The corpuscles in question had thrown off their membrane (if they ever had one,—for they seemed altered *young* corpuscles, or mere discs). It was therefore the nucleus of the corpuscle, which had become endowed with cilia; but this nucleus was quite red. The cilia presented the appearance of acuminated processes from the discs composing the corpuscles. It seemed to be by means of these, that the corpuscles in some instances slowly revolved, and in others changed their place. One of the corpuscles (β. fig. 104.) appeared to shoot forth a process, the cilium, which then as quickly disappeared, as if drawn in. Cilia could not be discerned on the corpuscle β, fig. 105. Yet one of its discs seemed to be in (incipient?) motion. We have elsewhere seen, however, that discs exhibit motion independently of cilia (par. 123.).

126. Besides the above, I have observed young blood-corpuscles (fig. 106.) performing constant and considerable locomotion; which, in some instances, was by no means slow. The motion of some resembled that known under the name of molecular, and others of these moving blood-corpuscles were so minute as to be comparable to molecules enlarged (pars. 198, 199.).

127. In a former communication[†] I described some most curious motions, or rather changes in form, observed under particular circumstances in corpuscles of the blood, and, in a note, added to that communication, stated that I had been induced to believe that those changes in form were referable to contiguous cilia. I ought now to state that subsequent observation enables me to say that these changes in form arise from some inherent power, distinct from the motions occasioned by cilia.

Molecular Motions discernible within Corpuscles of the Blood.

128. Minute red points around the nucleus within the blood-corpuscle, have been already mentioned, as observed in the Tadpole (fig. 75. α). Such points or globules exhibited molecular motions. The discs, formed apparently out of such objects, as in the corpuscle β of the same figure, did not exhibit motions, but were pressed together into polyhedral forms. In fig. 124. α, and fig. 123, globules such as those just mentioned appeared to be undergoing division. They at least presented the appearance of a rose, the same as that so often seen elsewhere. Molecular motions were exhibited by the globules contained within the cell fig. 102. I refer to the explanation of the Plates for an account of the circumstances under which these motions were observed; and have only to add, that the colour of the entire cell was precisely the same as that of the blood-corpuscles along with which it was observed.

129. It is known, through the researches of Henle, that the rete Malpighii consists of round cells furnished with a nucleus; which cells this observer, and subse-

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[†] On the Corpuscles of the Blood, Phil. Trans., 1840, Part II. pars. 12—18.

quently SCHWANN, succeeded in tracing into the cells of the epidermis. The latter supposes that a cell-formation takes place immediately on the surface of the cutis[†]. But here I cannot help referring to the process of division we have seen reproducing the epithelium-tables of the Tadpole; a process which it seems probable, from other of my observations, is universal, including, therefore, even the epidermis.

The Elements of Blood-vessels compared with Corpuscles of the Blood.

130. Capillaries in the course of formation out of corpuscles having the same appearance as corpuscles of the blood, are represented in fig. 107. These corpuscles, still red (α), apply themselves together so as to form an object resembling a necklace composed of elliptical beads; and having coalesced, and become pale (β), and the membranous partitions (at the extremities of the beads) having disappeared, they constitute a tube. The membrane of this tube is formed in the same manner as, according to my observations, the membrane of the ovisac, the chorion, and other membranes;—namely, by the coalescence of discs, as at α in the upper part of the above figure. At certain parts, the corpuscles apply themselves in such a manner as to form a branched vessel. An example of this is to be found in the figure; which also shows the corpuscles, coalescing in this instance for the formation of capillaries, to have been of very minute size. They had the same appearance as *young* corpuscles of the blood. At δ is a round space. This space was colourless, and brilliantly pellucid. And I am by no means sure that it was not an orifice left in the membrane of the tube (pars. 152, 162, 178.).

131. If the vessels have their origin in corpuscles of the blood, it is scarcely needful to inquire from what source they derive the materials for their thickening also, and for the formation of the several coats of which they become composed. It may be mentioned, that some of the pale discs in fig. 142.—evidently derived from corpuscles of the blood—seemed, by coalescence, to be entering into the formation of the membrane of the vessel. But here also, as appears to be the case in every other tissue, the original corpuscles (fig. 107.) no doubt contain within themselves the means of perpetuation.

132. While the investigations forming the subject of this memoir were in progress, I received a letter from Dr. W. B. CARPENTER, of which the following is an extract. It requires no comment, except the expression of my concurrence, as furnished by the foregoing observations:—"Having been just lecturing on the blood and the process by which it becomes organized, I think it well to mention to you some views which have occurred to my mind in reference to your observations on the conversion of blood-corpuscles into tissue[‡]. When *lymph* is thrown out upon an inflamed membrane, and is in process of becoming organized, it has been long known that the

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[†] SCHWANN, *l. c.*, p. 86.

[‡] Dr. CARPENTER here refers to my first paper on the Corpuscles of the Blood, Philosophical Transactions, 1840, Part II.

membrane beneath is usually much softened, and that its vessels seem to have a tendency to prolong themselves into lymph. Some have asserted that vessels and *red blood originate* in the lymph; but this has always appeared to me very doubtful. Now if your views be correct, I should see no difficulty in understanding that the vessels of the subjacent membrane prolong themselves, not by any *vis a tergo* (as some have supposed), but by the development of the blood-corpuscles stagnated in them first into cells and then into tubes, which convey blood into the coagulum; and this blood again contains the elements of a further ramification of capillaries, which will go on being formed in this manner, until a complete network is produced. It may be objected to this view, that coagulated *blood* ought to become organized more readily than *lymph*—which experience shows that it does not. But it may be replied that blood *mechanically* effused is in a very different state of vitality from the coagulable lymph or liquor sanguinis poured out on the surface of an inflamed membrane; and that these changes of the corpuscles do not take place in those of the clot or coagulum itself, but in those of the vessels in the living tissue beneath. It is very interesting to find a theory harmonizing with previous observations, which is I believe the case in this instance. Rows of corpuscles, proceeding from the red points of the subjacent membrane, have been seen in coagulable lymph; but their *import* was not known as I believe it now may be†."

The Elements of Cellular Tissue compared with Corpuscles of the Blood.

133. There is no tissue the elements of which resemble altered blood-corpuscles more than those of the cellular. And there is certainly no tissue which it is of more importance to trace back to such objects, than this; because of its presence almost everywhere in the body, either as cellular tissue, or in the more condensed state of the parts, into the formation of which it enters. This remark is of course applicable in a pathological, as well as in a physiological point of view.

134. On reference to figs. 109. 111. 112, it will be seen that the first changes visible in the formation of this tissue, are in no small degree like those presented by the incipient pus-globule (par. 101.). And this similarity we shall meet with again and again, as we examine the elements of other tissues. The corpuscle at α, fig. 109, presenting the same appearance as a slightly altered corpuscle of the blood, has one large orifice; in those at β there are two or more orifices of smaller size; and subsequently a number of bright points come into view. These points seem to be the cavities or depressions in as many discs, between which discs red colouring matter still lies, and conceals their margins. The bright points, therefore, *seem* as if contained in a mass of red colouring matter. The form of the corpuscle sometimes undergoes a considerable change, before the margins of the discs are distinctly seen, as in fig. 109. γ; where it presented the appearance of an elongated, flattened mass. The discs, however, are soon distinct (fig. 112. β, fig. 111.); and the explanation of

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† Dated Kingsdown, Bristol, Feb. 8, 1841.

the Plates will show that here, as in figures of the elements of other tissues, the transition from a corpuscle having the same appearance as a corpuscle of the blood, into a mass of discs, was quite unequivocal, in colour and in form, as well as in the gradual appearance of the discs. It is important to remark, that the mass of discs presents, not the entire corpuscle, but its nucleus enlarged.

135. This mass, already elliptical (fig. 109. γ), becomes pointed, and usually at both ends (figs. 110. 111, fig. 112. γ). The pointed extremity is then elongated into a filament (see the same figures); and apparently by the following means. The comparatively large discs into which the corpuscle has divided, undergo division and subdivision themselves, until discs are produced of extreme minuteness. These coalesce to form the filament; which has in its interior the means of perpetuation, through discs, into threads still finer. (This seems to be the general mode of production and thickening of membranes and fibres.) The elongation of the mass of discs into filaments, takes place sometimes in more than two directions. The whole mass of discs does not at once pass into filaments; but a part, enlarging, becomes a special centre, apparently for the origin of new substance (fig. 112. γ); as we saw in the epithelium, and pigmentum nigrum (pars. 119, 120.). But every disc, large enough to be discerned and traced, seems to exhibit a reproducing property.

136. The figures present examples of the elements of cellular tissue thus formed, from various parts, and, among others, from the thigh (fig. 109.), the neck (fig. 111.), and the axilla (figs. 112, 113.); as well as a drawing of this tissue, entering into the formation of the sheath of the spinal chord (fig. 116.). The fibres of cellular tissue forming this sheath seemed to be interlaced.

The Elements of the Corpus luteum derived from Corpuscles of the Blood.

137. In a former memoir[†], I described the Graafian vesicle as formed by the addition of a covering to the previously existing ovisac. The covering was stated to consist of a kind of dense cellular tissue, susceptible of becoming highly vascular. In a later communication, I came to the conclusion, that the covering of the ovisac becomes the corpus luteum[‡].

138. Confirming these observations, I have now to make the following addition. On examining the vessels entering into the formation of the covering of the ovisac, and rendering it highly vascular, in a rabbit killed three hours post coitum, I found them filled with blood-corpuscles in an altered state. The central part was greatly enlarged, colourless, and brilliantly pellucid; and the contour was lost by the slightest pressure, so that the red colouring matter of adjacent corpuscles had the appearance of being blended into a mass, filling up the interstices between their round, colourless, and brilliant centres. This condition of the blood-corpuscles within the vessels, too much resembled that which I had met with in other parts, formed out of corpuscles

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[†] Researches in Embryology: First Series. Philosophical Transactions, 1838, Part II. par. 24.

[‡] Second Series. Philosophical Transactions, 1839, Part II. par. 156.

having the same appearance as corpuscles of the blood, not to induce the belief, that it is the blood-corpuscles entering into the formation of the covering of the ovisac, which form the corpus luteum.

139. As long since as in the autumn of 1838, my friend Dr. Hodgkin mentioned to me a view entertained by him, that the blood sent to the enlarged Graafian vesicle, becomes the corpus luteum. This requires from me no other comment than that afforded by the observation now recorded.

The Elements of Cartilage and other Tissues compared with Corpuscles of the Blood.

140. The early stages in the formation of cartilage, which happen to have fallen under my notice, were observed in the foundation of a bone in one of the lower extremities of a fœtal chick, on the tenth day of incubation (figs. 119, 120.); in the foundation of a spinal vertebra from the same chick (fig. 122.); in that of one of the cranial vertebræ from a Tadpole of 5‴ (fig. 117.); in the foundation of the orbit in another Tadpole of the same size (fig. 121.),—this cartilage having been seen in a different state in a Tadpole of 6‴ (fig. 118.); and also in an incipient spinal vertebra from one of these larvæ. In these observations, a transition out of corpuscles having the same appearance as corpuscles of the blood, was either directly witnessed, or to be inferred. Such corpuscles, generally speaking, are not represented in the figures, because the cartilage was too far advanced. Yet in fig. 117, on the left side, there may be seen two remarkable corpuscles of this kind. The eye becomes so accustomed to the altered nucleus of the corpuscle, having the same appearance as the corpuscle of the blood, that it is scarcely requisite to see that corpuscle in an entire state. In these observations, however, there was not wanting the characteristic red. In fig. 119, for instance, this colour was recognizable after the nuclei had begun to arrange themselves into fibres; in fig. 122. the young corpuscles α, situated in the incipient cartilage of a vertebra, were blood-red; in fig. 117, on the left side, as already mentioned, is the outline of two elliptical corpuscles having the same colour and general appearance as the blood-corpuscles circulating in the vessels of the same larva (the Tadpole); and the red colour was noticed also in the objects of fig. 121.

141. It may here be remarked, that the corpuscles which, in the incipient cartilage fig. 117, had the same appearance as the blood-corpuscles of the animal, were situated in the most superficial part, as though *added* to corpuscles previously there. This was the case, also, with the young and red corpuscles α in fig. 122. And we shall hereafter find the same superficial situation to be occupied by the newest corpuscles entering into the formation of the optic nerve (par. 151.).

142. In examining the foundation of cartilage, the observer is struck with the regularity of distance between the nuclei of the corpuscles; this being referable, apparently, to the presence originally of the entire corpuscles (fig. 117.), the outer part of which afterwards disappears (fig. 121.); and a dense mass is formed, by continual additions from the nuclei, as centres for the origin of new substance. It seems to

have been on cartilage in this more advanced state, that observations heretofore have been principally made. And the figures given by SCHWANN of cartilage†, show, I think, the continued existence of centres of this kind.

143. A suggestion offered in one of my former memoirs‡, seems to have been realized by the observations recorded in this paper; for the elements of cartilage are certainly the seat of changes essentially the same as those we formerly witnessed in the cells succeeding the germinal vesicle in the ovum.

144. We also find that cartilage exhibits centres, such as those we have seen to exist in the epithelium (par. 119.),—in the black pigment of the eye (par. 120.),—in cellular tissue (par. 135.),—as are to be recognized, I think, in the "Ganglion-globules,"—and the most remarkable of which centres is the ovum. But in these special centres there is to be witnessed no other than the same process, as that which operates in the nucleus of every cell.

145. Fig. 116½. represents the outline of very large cells, filled with other cells. The large cells had the appearance of altered blood-corpuscles; the colour being also pale red. The nuclei were for the most part blood-red, and not distinguishable from young corpuscles of the blood (fig. 106.), lying near them. From the great length of the object formed by the large cells just mentioned, and from its general appearance, I am disposed to regard it as the foundation of the cartilage destined to form a bone; but the object, though consisting of large cells, was so minute, that an opinion here must be cautiously expressed.

146. The extremity of the incipient beak, as well as that of a claw, from a fœtal duck, on the 13th day of incubation, were found to be in a state of the same kind as the forming cartilage in fig. 119; and there was observed a transition out of corpuscles having the same appearance as corpuscles of the blood.

147. A like origin has seemed to be presented by the elements of feathers in the chick: but my observations here have been but few.

148. Though rather out of place, it may be mentioned, that in the Tadpole which yielded the drawing fig. 121, I saw what appeared to be the foundation of a ligament, also having an origin in corpuscles which presented the same appearance as corpuscles of the blood, and seemed to be arranging themselves into a fibre.

The Elements of Nervous Tissue compared with Corpuscles of the Blood.

149. The optic nerve in the Tadpole of $4\frac{1}{2}'''$ to $5'''$, seen as it is entering the eyeball, is very easily found, and there is not much danger of any other object being mistaken for it. My observations on the optic nerve, at this early period, have been very numerous, and, it may be added, highly satisfactory.

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† *L. c.*, Tab. I. figs. 5–9. Tab. III. figs. 1, 2.

‡ Researches in Embryology: Third Series, *l. c.*, par. 393.

150. Figs. 123, 124 and 125, present portions of this nerve in a more or less incipient state. The objects represented, chiefly in outline, in fig. 123, observed at a part of the nerve near its entrance into the eye-ball, were all corpuscles having the same appearance essentially as corpuscles circulating in the blood. I refer for a particular description of these to the explanation of the Plates. The nerve did not present any fibres; and so incipient was it, that at the part represented in the figure, the corpuscles had their original elliptical form. In another instance, where the nerve was rather more advanced, the globules surrounding the nucleus (see the corpuscle more finished in delineation than the rest in fig. 123.), had very much disappeared, and the corpuscles were pressed into polyhedral forms.

151. In a former page, I mentioned that the foundation of cartilage had presented an appearance, suggesting, from the more advanced state of the interior, that corpuscles had been *added* at the outer part. Such an appearance is even more remarkable in the optic nerve, as shown in fig. 124; all the objects in which (presenting, it will be seen, very different states) were observed in the same nerve. I have stated that the corpuscles in fig. 123. had *essentially* the same appearance as that of corpuscles of the blood. Respecting those at α, in fig. 124, it may be said that their appearance was *precisely* such as that of corpuscles circulating in the blood of the same larva. Yet the interior of the nerve in this instance was in a more forward state than that of the one before referred to (fig. 123.); the other objects in fig. 124. having been composed of discs (some of them forming necklace-like objects, or incipient fibres), derived from the nuclei of corpuscles, such as those just mentioned (α). These discs were all red; the colour being paler in the more advanced. (See the figure and the minute explanation of it.)

152. Portions of this nerve, in a more advanced state, are seen in fig. 125. The discs at α, into which the nuclei of the corpuscles had divided, were arranging themselves in something like lines. They presented minuter discs in their interior, as in the part represented less in outline than the rest. The tube β, yet more advanced, was forming out of discs, which were coalescing at its periphery. These discs, corresponding apparently to the minutest of those at α, again, presented other discs in their interior. Pellucid points, apparently orifices, were seen here and there. They seemed to communicate with the exterior of the tube (pars. 130, 162, 178.). These pellucid points correspond to the depressions in the original discs. As in muscle, there are doubtless in the interior of an object such as β, the elements of new substance,—the essential portion of the nerve.

153. In these researches, a considerable share of my attention has been devoted to the elements of the retina; which afforded ample proof of their origin in corpuscles, having the same appearance as corpuscles of the blood. Some of these elements are represented in figs. 126 to 131; and it will be seen that they are of the same character, whether taken from the fœtal Calf, fig. 130, or from the Tadpole, fig. 131; consisting, in both, of round, flattish masses of discs.

154. Here also, corpuscles having the same appearance as young corpuscles of the blood, become orange-shaped, present two or more bright points with red colouring matter between them (see the figures); and, as the colouring matter disappears, admit of being traced into the masses of discs just mentioned; these being the altered nuclei of the corpuscles in question. We thus find in the elements of the retina, as well as in those of cellular tissue (par. 134.), the same appearances as those presented in the formation of pus-globules out of corpuscles of the blood.

155. After the corpuscle, having the same appearance as corpuscles of the blood, has become a mass of discs, the discs may undergo division and subdivision to an inconceivable extent, and to which we can set no bounds, as regards either the number or the minuteness of the resulting objects. It will be observed, from fig. 130, that cells are formed; their membranes arising—as elsewhere, according to my observations—from the coalescence of minute discs. These cells will be found minutely described in the explanation separately given. It is not my purpose in this memoir to follow their subsequent progress.

156. I have frequently met with the rudiment of the spinal chord,—sometimes in fragments, sometimes almost entire,—as it exists in the tail of the Tadpole; this larva measuring $5'''$ or $5\frac{1}{2}'''$. Its newest part I found composed entirely of corpuscles having essentially the same appearance as corpuscles of the blood, and being in a state resembling (but somewhat more advanced than) that which they presented in the optic nerve fig. 124 α, and also arranged in lines. In fig. 132. is an outline of some of the corpuscles which I observed constituting this structure in a Tadpole of $5\frac{1}{2}'''$. The spinal chord has uniformly appeared to be less advanced than the cellular tissue which seemed to be entering into the formation of its sheath (par. 136.).

157. Corpuscles from the cortical substance of the brain in a fœtal Calf of $5\frac{1}{4}$ inches, are seen in fig. 133: and fig. 134. represents some of those observed in the medullary part of this organ, in the same subject.

158. Objects such as those in the first of these two figures, were observed in large number; and often seen to be flattish in their form. They were all more or less red,—some blood-red; all were either discs, or composed of discs,—being either themselves corpuscles, having the same appearance as corpuscles of the blood, or immediately derived from such corpuscles. Here, as often observed in other parts in the course of formation, the corpuscles were found to be of a minute size; being apparently young corpuscles. They presented the same gradual transition into the elements of the brain, as we have seen in other parts, regarding a change in form, colour, and division into discs; besides the previous appearance of an orifice (β), in the situation of the depression presented by the corpuscle when discoid in its form. The gradual formation of a membrane too, by coalescence of the outer discs, was witnessed here (η). These details will be found more fully given in the explanation of the Plates. And perhaps there is no figure more instructive, as regards the changes

presented by the corpuscle or disc,—its passage into *layers* of discs,—the comparative age of these,—the reappearance of red colouring matter,—and the *secondary* nature of the "cell," than the figure now before us—fig. 133. To the description of this figure, in connection with that of fig. 134, I particularly refer.

159. Very much the same general remarks apply also to the elements of the medullary portion of the brain (fig. 134.).

The Elements of Muscular Tissue compared with Corpuscles of the Blood.

160. Some of the earliest appearances presented by muscle, in its formation out of blood-corpuscles, were given in one of my former communications to the Society[†]. The muscles then examined, being involuntary, did not afford so interesting a field for observation, as those the development of which has since had my attention,—the voluntary muscles; nor did I then prosecute the investigation farther than as opportunity was incidentally afforded. Nevertheless, it will be seen that the facts I have now to mention, accord with those stated in that memoir.

161. Corpuscles more or less blood-red, and having the appearance of young blood-corpuscles, apply themselves to one another in the manner represented in fig. 135, and also in the memoir just referred to; by which a necklace-like object is produced. These corpuscles are cells, which I have found filled with discs (β). The appearance of these discs, together with that of the nucleus and nucleolus, resembled in a remarkable manner the corresponding parts in certain states of the germinal vesicle and germinal spot[‡]. In no instance have I more clearly seen the nature of the so-called "nucleolus" of authors; and that at this part there exists an orifice, communicating with the exterior of the cell (fig. 135. β). By degrees, the appearance of a cylinder is produced (fig. 136.), which becomes more perfect, as the partitions between the cells, just mentioned, disappear—fig. 137. In this figure, nuclei are still seen, having a parietal situation; these being, as SCHWANN supposed, the nuclei of the original cells (fig. 135.). It must not, however, be supposed that no change takes place in the nuclei; or that the nuclei seen in such a stage as that in fig. 135, are *identical* with those presented in the later state, fig. 137. It appears to me that the nuclei in the later state, merely occupy the same place as those in the earlier. For here, in the muscle-cylinder,—or as SCHWANN has termed it, the "secondary" cell,—the same process is in operation as, according to my observations, is seen everywhere else in what have been called the primitive cells; namely, a continual change in the nucleus. A part continually passes off in the form of discs, which are contained within the cylinder; while a fresh supply of discs is continually coming into view around an orifice, connecting apparently the interior and exterior of the muscle-cylinder, or "secondary cell." This *orifice*, however, appears to be identical with that existing in the original cells, fig. 135.

[†] On the Corpuscles of the Blood, Philosophical Transactions, 1840, Part II. p. 595.

[‡] Compare β of fig. 135, with c of fig. 160, in my Third Series on Embryology, *l. c.*

162. It is to VALENTIN and SCHWANN that we are indebted for the observation, that the muscle-cylinder is formed of nucleated cells. But the other facts now mentioned[†], I believe are new; namely, the more or less blood-red colour of the original cells (fig. 135.), the presence of discs in their interior, the derivation of these discs from the nucleus, the existence of an orifice at a certain part of the nucleus, and a continuation of these appearances in the muscle-cylinder, or "secondary[‡]" cell. We may hereafter see reason for thinking it not unimportant, that the contents of the "primitive" cell, and those of the "secondary" cylinder, should have their origin in the nucleus; as well as to connect this fact with the existence of the orifice in question. The muscle-cylinder thus contains centres such as we have seen elsewhere[‡] (pars. 130, 152, 178.).

163. The discs filling the muscle-cylinder, are the seat of elaborate changes; as is to be inferred, I think, from the very remarkable appearances they afterwards present. These appearances will form the subject of a future memoir, which it is my intention to offer to the Society; for I feel it incumbent upon me, because due to the Society, to show that certain conjectures in one of my former papers, printed in the Philosophical Transactions, have been fully realized.

The Elements of the Crystalline Lens compared with Corpuscles of the Blood.

164. If there is any structure which it would at first sight seem impossible to trace back to corpuscles having the same appearance as corpuscles of the blood, that structure is surely the crystalline: and none but the most conclusive evidence will suffice, to prove that this admits of being done. Whether the observations I have to offer are of this character, the future must determine. I can only say that they were repeatedly confirmed.

165. I am enabled to verify Professor SCHWANN's description of the pale cells of the crystalline; except as regards the nucleus, nucleolus, and contents of the cell. (But in these respects my views are peculiar, with reference to "cells" in general: a remark applying also to the mode of formation of the membrane of the "cell," to the manner in which cells are reproduced, and to the secondary nature of the "cell" (par. 173.)). My observations also corroborate his view, that the foundation of the fibres of the lens consists of cells. But they do not enable me to adopt the

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[†] Though merely an extension of those I formerly communicated with reference to the ovum.

[‡] In later stages there exist other centres for the origin of new substance within the cylinder; and chiefly in its central part. Some of these have been figured by SCHWANN (*l. c.*, Tab. IV. figs. 1, 2.), and especially by BOWMAN (Philosophical Transactions, 1840, Part II. Pl. XVIII.), who denominates them the "corpuscles of the primitive fasciculi." I recommend particular attention to the observations of the last-named author, on these corpuscles (*l. c.*, pp. 484, 485.). He considers it "not impossible that" *** "there may be during development and subsequently, a farther and successive deposit of corpuscles, from which both growth and nutrition may take their source" (*l. c.*, p. 485.). In this I concur; and may add, that the process we saw in operation in the germinal spot, and, as above described, in muscle,—is no doubt applicable to each of the corpuscles observed by BOWMAN; which in my opinion are continually reproduced by division.

opinion of this eminent observer, that the fibres are *elongated* cells. The mode in which the fibres seem to me to form out of cells, will be hereafter mentioned. The first, and more important question is, what is the material furnishing the cells, and therefore the fibres of the lens? It is here needful to make a few preliminary remarks.

166. Slices cut from the surface of the lens in the fœtal Calf and Sheep, have presented to me in the microscope, not only red blood, but young blood-corpuscles, as well as the parent-corpuscles from which they were escaping. Seldom have I had so favourable an opportunity for observing the manner in which the blood-corpuscle is perpetuated (fig. 141. δ δ), and for making the observations I have now to mention,—that the young blood-corpuscle has a peculiarly bright colour, and—though in Mammalia—an elliptical form. The young corpuscle soon becomes round, though at first it continues flat; the latter no doubt answering an important end connected with its motion in the vessels.

167. Fig. 141. affords a proof that the diameter of the corpuscles usually seen in circulation, is no criterion by which to judge whether red blood can make its way into parts generally considered colourless. For, at α, a portion of vessel is filled with corpuscles, having a diameter not much more than half of that usually ascribed to them: the fact being that, besides the minuteness of the objects into which blood-corpuscles may divide, the form of the corpuscles is susceptible of every change; and minute indeed must be the orifice they could not be made to enter, so attenuated is the shape they sometimes assume. It may be also added, that I have observed a capillary forming, the diameter of which measured only $\frac{1}{700}'''$, which indeed was about the size of some of those in fig. 141: and I have seen objects having precisely the appearance of blood-corpuscles, of less than $\frac{1}{1000}'''$. Mere points too, are found, having the red colour of the blood, and we have already seen that minute objects exhibiting molecular motions, may be observed within corpuscles of the blood (par. 128.); as well as that young corpuscles of the blood are met with, exhibiting motions comparable to that called "molecular," and so minute indeed as to have the appearance of "molecules" enlarged (par. 126.).

168. Corpuscles having the same appearance as young blood-corpuscles, are also seen within tubes—fig. 144. And this figure shows that, while the red colouring matter was still present in some, it had disappeared in others,—the latter being represented in outline only.—Other states of the corpuscles are observed, also within tubes, as in fig. 149. They here exhibited the same division into discs which we have found to take place elsewhere: and while some of the corpuscles undergoing this division were blood-red, others were becoming pale. A farther change is met with: the masses of discs, derived from such corpuscles, seem to be arranging themselves into lines, as if to form fibres (fig. 150.).

169. I have seen red capillary vessels on the posterior surface of the lens. Here the vessels radiated from central trunks, *towards the margin* of the lens. One of

these vessels is seen in fig. 142. It was a branch, proceeding from a trunk more than three times its diameter.

170. In delicate, flat, and branchless tubes, from the edge of the lens—where red tubes have presented to me a parallel direction, from behind forwards—I have found corpuscles, having the same appearance as corpuscles of the blood, arranged with curious regularity; their flat surfaces being in contact with one another (fig. 145.). These corpuscles were blood-red, and red colouring matter was seen between or around them. For other particulars respecting these corpuscles, I refer to the explanation separately given, and to figs. 146, 147, 148; here mentioning only the brightly pellucid object in the situation of the original cavity or depression in the corpuscles. I may return to the subject of the corpuscles in these figures, in a future communication.

171. In figs. 151, 152, are portions of tubes, also from the edge of the lens. These figures are almost entirely in outline. Tubes are very frequently met with, having their contents (which resemble altered blood-corpuscles) in this state. The pellucid object arising in the centre of the corpuscle, is originally round (fig. 151.). It appears that these pellucid objects enlarge, and then coalesce with one another; the red colouring matter at the same time disappearing. By this means transparent, colourless, and very bright spaces are produced; sometimes so large as to occupy a very considerable, and even the principal, portion of the tube. But here again I must refer to the explanation of the figures; remarking only, that there was visible in some of the pellucid spaces (in fig. 152.) a minute, highly refracting object (δ), apparently an orifice communicating with the exterior of the tube (δ δ). Tubes with contents such as those in fig. 152, vary much in their diameter at different parts. I met with a tube of this kind, which, at one part measured $\frac{1}{100}'''$, then decreased to $\frac{1}{200}'''$, and then again enlarged to $\frac{1}{100}'''$: and all this variation in the diameter of the tube, was observed within $\frac{1}{10}'''$ of its length. I have frequently noticed corpuscles, having the appearance of altered corpuscles of the blood, some of which had perhaps escaped from such tubes as those last referred to. Some of these corpuscles are seen at θ and ι, fig. 142, and in fig. 143.

172. In figs. 153, 154, 155, 156, are pale cells, such as those constituting the foundation of the crystalline. As was observed by SCHWANN, there is a nucleus in many of these cells; but, as he likewise saw, there are very many in which no nucleus is found. On very closely examining the cells which had no nucleus, I have thought many of them filled with discs (fig. 153.). These discs (if I was not mistaken in the observation) had no doubt resulted from a division of the nucleus of the cell. But the cells are so very pale, that often nothing can be discerned in their interior. In figs. 156 and 159, a nucleus is seen to have divided into two parts; each of which was a disc, and presented an indication of subdivision into other discs.

173. Besides confirming, in this way, my opinion as to the mode of origin of the

contents of "cells" in general, an attentive examination of these pale cells of the crystalline has also strengthened a view mentioned in my last memoir[†],—that, however minute the "cell," and wherever it exists, it is by the coalescence of discs that its membrane is formed. Thus in fig. 156. α, β, the outer discs are seen entering into the formation of the membrane of the cell; the remainder being now the nucleus of the cell. At β, fig. 154, the cell-membrane is formed. We thus seem to have even here a mode of origin of the membrane of the cell, essentially the same as that which, in a former paper, I showed to form the chorion[‡],—as will be hereafter pointed out in the membrane of the ovisac,—and as seems to be the mode of production of other, and perhaps all, membranes, as well as fibrous tissues.

174. Other facts observable in an examination of the pale cells of the lens, are equally confirmatory of my views regarding "cells" in general. The nucleus is very distinctly seen to be composed of discs (figs. 154, 155, 156.), into which it divides; and at a certain part, there is sometimes seen a highly refracting object, corresponding apparently to the nucleolus of authors, but, as I believe, being really an orifice communicating with the exterior of the cell.

175. I have already mentioned my inability to confirm the idea of Professor Schwann, who supposed it to be by *elongation*, that these pale cells form the fibres of the lens. It is true he makes the addition, "I have several times observed the arrangement, one upon another, of the nuclei of cells; but do not know what it indicates. It is also very possible that the coalescence of cells may take place to form a fibre; but hitherto I have no decisive observations[§]." It affords me satisfaction to find that, while bringing forward facts opposed to the views of this excellent observer, I am not without an admission—very important as coming from him—of the possibility that the fibres may arise by another mode.

176. It remains to add, that the appearance now and then, in very large numbers, and in parallel lines, of objects such as those in figs. 157, 158, 159, has led me to believe that the fibre of the lens is formed by the *coalescence of the cells in question, previously arranged in a line.*

177. These fibres in many instances originally present the nucleus in their cells (see the figures). Sometimes the so-called nucleolus—really an orifice—is also present (figs. 157, 158. α), communicating with the exterior of the cell. In another instance (fig. 157. δ), I saw the cell filled with discs, there being no nucleus in this cell.

178. The fibres are originally of a necklace form; their bead-like segments being often of unequal magnitude (see the figures). When this is the case, deficiency in size is sometimes compensated by the number of the cells (fig. 158. β). It is probable that in other instances an equal diameter throughout the fibre, is obtained by elongation of the larger cell. Sometimes the cells are very large (fig. 159.). The bead-like segments coalesce; the intervening membranous partitions disappear; and thus

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[†] On the Corpuscles of the Blood, Part II. *l. c.*, par. 79.

[‡] Researches in Embryology: Third Series, *l. c.*

[§] *L. c.*, p. 102.

a cylinder is formed. In the parietes of this cylinder I have noticed pellucid objects, possibly denoting the continued existence of the orifices above mentioned, as present in the nuclei. If such has been the case, it would appear that there exist communications between the interior and the exterior of the cylinder (pars. 130, 152, 162.). At all events we cannot doubt but that here, as in muscle (par. 161.), the nucleus of the original cell is the source from whence the contents of the cylinder immediately proceed: and that here, therefore, as elsewhere, we have special centres for the origin of new substance.

179. The main question, however, continues,—are the cells we have been considering, derived from corpuscles having the same appearance as corpuscles of the blood? At the surface of the lens, we saw an abundance of young corpuscles forming for some special purpose, and corpuscles, having a similar appearance, exhibiting very remarkable internal changes. Other changes are represented in fig. 155; the objects in which figure, found at the edge of the lens, had the same appearance as altered corpuscles of the blood. The two in outline (*α*) exhibited the characteristic red, as well as the general appearance of blood-corpuscles, in an unaltered state; excepting only, that in their irregular contour, there were some indications of a future division into discs. *γ* was a flattish corpuscle, composed of discs, and still blood-red. The objects *δ*, *δ* resembled *γ*, but were larger. The nuclei of the cells *ε*, *ε*, *ζ*, *η*, were quite red enough to show their origin to have been in corpuscles having the same appearance as corpuscles of the blood. All the objects in this figure thus presented red colouring matter,—which in *α*, *β*, *γ*, *δ* pervaded the entire object, but in *ε*, *ζ*, *η* was confined to the nucleus of the cell. The more or less incipient cells of fig. 156, were obviously altered corpuscles having the same appearance as corpuscles of the blood. And the remark just made, respecting colour, applies to the nuclei observed in the other cells above referred to as the elements of the crystalline (fig. 154.), as well as to the nuclei of those cells which we have seen arranging themselves to form its fibres (figs. 157, 158, 159.).

180. These are the principal observations, which have induced me to believe the crystalline lens to be derived from corpuscles of the blood. And, upon the whole, I should find it difficult to point out a line, separating the one from what are allowed to be the elements of the other.

181. It may be added, that among the figures there will be found three outline sketches (figs. 138, 139, 140.), representing appearances incidentally observed, in the course of my examinations of the Tadpole. The first of these, in a Tadpole of $5'''$, seemed the foundation of the crystalline, as it lay, surrounded by black pigment, and imbedded in the vitreous humour. It had the appearance of an altered and prodigiously enlarged corpuscle of the blood; being throughout red, except at the anterior part, *α* (where it was colourless and pellucid), and being filled with discs, resembling those arising in the interior of corpuscles of the blood. At the part marked *β*, these discs were largest, and of the deepest red. This appearance, together with those

exhibited in figs. 139, 140, observed in similar situations in others of these larvæ (for a particular account of which I refer to the explanation of the Plates), induce me farther to believe that the crystalline may have its origin in a *single* corpuscle, having the same appearance as a corpuscle of the blood.

The Elements of the Spermatozoon and those of the Ovum compared with Corpuscles of the Blood.

182. I had made the principal part of the foregoing observations,—when two others followed, which had not been at all anticipated. For, although the facts observed had led me pretty nearly to the conclusion, that every tissue in the body has its origin in corpuscles having the same appearance as corpuscles of the blood,—yet the thought, I confess, had not occurred, that the spermatozoon and the ovum might be immediately derived from the same source. It was not until the red colouring matter was noticed, by which I recognized corpuscles having the same appearance as altered blood-corpuscles, in some seminal fluid under examination, from the testis of a Bird, that the idea suggested itself, and led to a farther examination.

183. The experience gained during the long investigations, the principal results of which have been mentioned in the preceding pages, now make it easy for me to see that the "granules" which previous observers had noticed in this fluid, were masses of discs, or rather, cells filled with discs,—the altered nuclei of corpuscles having the same appearance as corpuscles of the blood. And on examining the ovary, I became equally convinced, that the object figured by myself in the Royal Society's Transactions three years since, as the ovum in a rudimental form,—while it admitted of delineation just as I then represented it,—was also derived from the same source.

184. I need scarcely mention the satisfaction afforded by these two additional observations; not only on account of their being in themselves in the highest degree interesting, and, as it appeared to me, important,—but because of the confirmation I of course believed them to give to all the rest.

185. In passing into the granular mass, or more properly, into the cell filled with discs (fig. 160.), where the spermatozoa seem to form, the nucleus of the corpuscle in question presented to me appearances in some respects similar to those which I had met with in tracing it into tissues. But I was perhaps more struck with the depth of the red colour, in the more advanced elements of spermatozoa that fell under my notice. The object fig. 161, for instance, was of a deep red. I have seen these seminal "granules" in some of the Mammalia; certain of them appearing to contain incompletely formed spermatozoa.

186. The view, however, just propounded implies another; which, so far as I know, is also new. The so-called spermatozoon appears to me to be composed of a few coalesced discs. Such has appeared to be its condition in the Rabbit, and in certain Birds. Of course the different forms of spermatozoa in different animals, sug-

gest variety in their particular mode of origin. But I have no reason to doubt that the foundation of spermatozoa in general consists of the objects I have denominated discs.

187. The corkscrew-like spermatozoon of certain Birds has presented to me appearances, which it seemed worth while to delineate (figs. 162, 163.); and I recommend that the description of these figures should be referred to; leaving it, however, for the future to determine, whether the curious division of discs in a longitudinal direction, there suggested, really takes place.

188. In a former page, I referred to a parent corpuscle (fig. 94. α) having the same appearance as the corpuscle of the blood, filled with young corpuscles, which had been destined to form epithelium-cells. I have now to mention that young corpuscles are met with, while still within their parent cell, manifesting a very different destination. The cell in fig. 164. is a parent corpuscle having the appearance of an enlarged corpuscle of the blood; and each of the contained objects is a young corpuscle. But each of these young corpuscles is also a rudimental ovum. (Compare with the ovum in my First Series on Embryology, *l. c.*, Plate V. fig. 19.) The objects also in fig. 165, though mere *discs* having the same appearance as blood-discs, are rudimental ova. Those in figs. 166, 167, 168, 169,—presenting the ovum in states somewhat more advanced,—are also altered corpuscles having the same appearance as corpuscles of the blood. Even the most forward of the objects now referred to, presented red colouring matter quite sufficient to show, to an eye accustomed to these investigations, from whence they arose. But besides this, they admitted of being traced back into corpuscles having the same appearance as corpuscles of the blood (figs. 164, 165.). And all the objects in question, it may be added, were from the ovary of the same individual Bird.

189. The essential part of the ovum in these figures, is that marked *c*. It is the germinal vesicle: very much in advance, it will be observed, of other parts, in the degree of its development (see its large size in fig. 169. γ); being, as I originally said, the first part of the ovum which is formed. Its progress admits of being traced, from merely a pellucid space—the centre of a corpuscle having the same appearance as a blood-corpuscle, fig. 165. α—through the discoid form, as in the centre of the corpuscle β—to the state of an incipient cell, as in γ of this, and in some of the other figures. I have seen the future germinal vesicle, as a disc, measuring in diameter no more than $\frac{1}{700}$th of a Paris line (figs. 164, 165.).

190. The most essential part of the germinal vesicle, is seen in many of the figures which represent the latter. While the future germinal vesicle is a mere disc, its most essential part is the depression in the centre of the surface of this disc: and when the future germinal vesicle has really become somewhat vesicular in form, there is seen an orifice in the same situation (figs. 165 γ, 166, 167.). This orifice denotes the situation of the essential part of the germinal vesicle,—the future germinal spot.

We thus find that in the minutest details, such as those which I have elsewhere described, the germinal spot and vesicle are formed like other nuclei and cells.

191. I long found it impossible to understand in what way the membrane of the ovisac, as I termed it, was formed around the mass of peculiar granules having the germinal vesicle in its interior[†]; and equally difficult to conceive the mode of origin of the discus vitellinus, the true yelk, and the membrane of the yelk. It now appears to me that all these (as well as the germinal vesicle and spot) originate in a corpuscle having the same appearance as a corpuscle of the blood. That part of this corpuscle which surrounds the germinal vesicle (see the figures), becomes the source of the peculiar granules (as I formerly termed them) by which this vesicle is surrounded. These peculiar granules—the objects subsequently contained within the ovisac—are not originally cells: so that the term granule proves to have been not inappropriate. The fact is, they are *discs*, having the same form and general appearance as discs in other situations (only being very red); and by a change the same as that we have so often seen elsewhere, assume a cell-like appearance, and are reproduced in the same manner as other discs. Hence, in advanced states of the ovisac, the quantity of these objects becomes very large: and, as we formerly had occasion to observe, they arrange themselves into structures, some of which—the retinacula—enter into the formation of the mechanism regulating the expulsion of the ovum[‡].

192. But my purpose in referring to these discs so fully in this place, is to be enabled to make the following addition: namely, that they also give origin to the membrane of the ovisac, the discus vitellinus as well as the true yelk, and the membrane of the yelk. And as the discs in question are derived from a corpuscle having the same appearance as a corpuscle of the blood, so therefore are all these objects.

193. Delineations are given of the membrane of the ovisac thus forming. In figs. 170 and 171. the discs (*g*), quite red and large where in the neighbourhood of the germinal vesicle (*c*), were undergoing division; the young and paler discs passing outwards, increasing in size, dividing in their turn, then enlarging, and coalescing to form the membrane (*h*) of the ovisac. Traces of these coalesced discs, as well as a tinge of red, are to be discerned even after the ovisac has attained a considerable size; producing the appearance which, when first describing this membrane, I compared to that of plaits or folds.

194. I do not think that there is any essential difference between the discus vitellinus and what is called the true yelk: at least it would seem difficult to draw a line between the two. Where it is required to provide before-hand a stock of substance for fœtal use,—as in many of the Ovipara,—the discs *g* are made to form the yelk in

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[†] First Series on Embryology, *l. c.*, pars. 14, 23.

[‡] It may now be added, that the delicate membrane I described as sometimes seen investing the retinacula, and reflected from their branches to the membrana granulosa, seems to be formed by the coalescence of some of these discs.

large quantity. But in viviparous animals, these discs appear to produce little more than an object corresponding to that which in the Bird, for instance, has the form of the discus vitellinus. Fig. 173. presents these discs (*g*) rapidly dividing for the formation of the yelk in the Bird.—I refer to my First Series on the Embryo (*l. c.*, Plate V. fig. 25. *e*) for the earliest appearance of the membrane of the yelk.

195. The very minute ovisacs, myriads of which I described as found in the walls of the Graafian vesicle, seem to owe to the following circumstance their parasitic situation. The covering acquired by the ovisac consists of cellular tissue. Cellular tissue is formed out of corpuscles having the same appearance as corpuscles of the blood. But each of the minute ovisacs was once a young corpuscle of the same kind. And it appears that, while some of these corpuscles enter into the formation of the cellular tissue investing a large ovisac, other corpuscles are developed into smaller ovisacs, which therefore are found in the interstices of that tissue.

196. I have already stated that the individual discs exhibit a reproducing property. This is the case as well with those discs that have begun to enter into the formation of a structure, as with those not yet appropriated,—that is, still in circulation. With regard to the former it is to be remarked, that, in many parts, red colouring matter is reproduced along with the new discs (par. 111.), giving them quite as deep a colour as the floating corpuscles themselves; which in other respects also they resemble. Hence my general employment of the expression, *having the same appearance as* corpuscles of the blood: for it was impossible to distinguish those corpuscles which had been themselves extravasated; and I presume that, generally speaking, the term "corpuscles *of the blood*" would have been inapplicable to others, though immediately descended from them.

197. *Recapitulation.*

1. The nucleus of the corpuscle of the blood admits of being traced into the pus-globule.

2. The various structures arise out of corpuscles having the same appearance, form, and size as corpuscles of the blood.

3. The corpuscles having this appearance, and giving origin to structures, are propagated by division of their nuclei.

4. The corpuscles of the blood, also, are propagated by division of their nuclei.

5. The minuteness of the young blood-corpuscles is sometimes extreme; and they are to be found in parts usually considered not permeable by red blood.

POSTSCRIPT (June 23, 1841).

198. Blood found in the heart (immediately after death by bleeding) often presents incessant alterations in the position of its corpuscles. When one of the corpuscles is

examined very attentively, it is seen to change its form; and I am disposed to think it is this change of form that produces the alterations in position. The changes of form are slight, as compared with those referred to in par. 127, and are not seen without close attention. The motions resemble that called molecular, and in the minutest corpuscles, which are mere points, nothing besides molecular motion can be discerned. It may be a question, whether molecular motion differs in its nature from the motion of the larger corpuscles just referred to. The division of the blood-corpuscles into corpuscles of minuter size, though apparent in blood from either side of the heart, has seemed more general in that from the left side; which is perhaps deserving of notice in connection with the subject of respiration.

199. (*October*, 1841.) As explanatory of the foregoing paragraph, I may perhaps be permitted to mention some appearances that have since fallen under my notice. It is necessary, however, to apprise the reader that the remarkable appearances about to be detailed are not all of them to be always found; and indeed that sometimes most if not all of them are absent. To what circumstances their presence or their absence is to be attributed, it would be premature at this time to speculate, without facts that are still wanted regarding the action of the atmospheric air upon the blood-corpuscles in their passage through the lungs; and some unknown change which, from observations not yet completed, I am inclined to think these corpuscles undergo in that portion of the circulating fluid which passes through the liver. Neither am I in possession of facts connected with the process of digestion, which may possibly influence the reproduction of the blood-corpuscle; supposing this reproduction to be effected in the way suggested by the observations of the foregoing paper, and my previous memoirs. And here I am reminded to mention, that some of the animals from which the blood in question (after death) was taken, had not received food for many hours previously. Such were the sheep at the London slaughter-houses. In these instances, therefore, the minute objects about to be described cannot be referred to the formation of chyle, and its addition to the mass of blood.

Without attaching undue importance to the circumstance, it should be stated that the blood presenting the corpuscles about to be described, was taken from the left auricle, and therefore had recently passed the lungs. In the first place, I have at different times found that there exist corpuscles much larger than the rest, and a few of them of prodigious size ($\frac{1}{50}'''$). They are, as I have seen them, always *very pale, and sometimes even colourless*. They are obviously membranous at the surface. You sometimes see them ruptured, and partially discharged of their contents. In this state, they frequently appear shrivelled. When not ruptured they are distinctly filled with young corpuscles. Secondly. The young corpuscles after liberation from the parent corpuscle, and sometimes before that change, are seen to have acquired red colouring matter. When so liberated and individualized, they present a star-like form resembling that in figs. 104 and 105. This form I have in some instances noticed them to have while within the parent corpuscle. In a good light, these star-like corpuscles are evidently seen to be compound objects, consisting of about half a dozen segments. Each of these segments sends out a cilium; and it is by this means that the appearance of a star is produced. It is often possible to perceive these star-like corpuscles effecting alterations in their form, slowly revolving, and performing locomotion. Thirdly. Besides the two orders of corpuscles now described I have seen a third, of minuter size, apparently arising by division of those last mentioned; of which, therefore, they must have been the separated segments. Their motions were extremely vivid, and of such a kind as might be produced by the rapid vibrations of a tail-like appendage or cilium. Such cilium each of them would possess if they arise, as I think they do, by division of the ciliated corpuscles above described. Fourthly. Many corpuscles also, about the size of those last mentioned, are to be seen in the same fluid, of a star-like form. Lastly. There are others, so immeasurably small as to appear as mere points. They have precisely the same colour as corpuscles of larger size, and exhibit most vivid motions.—Some of the states now described, I have seen in the blood of the Common Mussel.

200. Explanation of the Plates.

PLATE XX.

Fig. 63. Man. Corpuscles found in fluid having nearly the colour of blood, taken from an abscess. This figure shows the young corpuscle of the blood becoming changed into the pus-globule. See par. 101. for the details of this change. In the objects presented by this figure, proceeding from left to right, a gradual enlargement was observed, as well as a change from the flattened to the globular form; and those on the extreme right had lost, in some degree, the peculiar tint characterizing the corpuscle of the blood. (The more or less altered blood-corpuscles in the fluid from which this figure was taken, were observed to arrange themselves into rouleaux, like those in blood unaltered.)

Fig. 64. Man. Globules and cells from well-formed pus, after the addition of (α) acetic acid, and (β) dilute spirit.—α. The largest globule was still surrounded by, and eccentric in, an elliptical cell, which is shown in outline. A corresponding cell had perhaps disappeared from around the other globules; for many such cells were seen in this pus, before any addition had been made. When a cell is present, the pus-globule is the nucleus; and its eccentric, highly refracting portion, is the nucleolus. The pus-globule is composed of elliptical discs; those forming the nucleolus having a high refracting power, after, as in this instance, the addition of acetic acid. The nucleolus consists of either a

single disc, or two or three discs. Where the discs of the nucleolus lie one on the other, the degree of refraction is very small. β. Similar objects, as viewed after the addition of dilute spirit. Each of the two lower ones has the appearance of being circumscribed by a membrane, and is contained within a minute cell. The upper object presents three layers of discs; the outer layer being pale.

Fig. 65. Man. Fragment of a capillary vessel, found in the pus of the preceding figure. It is filled with altered corpuscles of the blood. The largest corpuscle presented an appearance resembling that of the pus-globule. (Acetic acid.)

Fig. 66. Man. Altered blood-corpuscles, observed in fluid from abscesses.

Fig. 67. Man. Altered blood-corpuscles, observed in fluid from the intestinal canal, where the existence of pus was suspected (compare with fig. 63.). α Corresponds, apparently, to the "lymph-globule" of authors.

Fig. 68. Man. Globules and cells in mucus from the air-passages of a healthy person. This mucus had in some parts a slight tinge of yellow. (Acetic acid.)

Fig. 69. Man. Globules and cells in mucus from the air-passages of a healthy person. This mucus was a tenacious, colourless, pellucid fluid. (Acetic acid.)

Fig. 70. Man. Cells in mucus from the Schneiderian membrane. The discs blood-red. (Acetic acid.)

Fig. 71. Man. A later stage of apparently corresponding objects, taken from the same part. (Acetic acid.)

Fig. 72. Man. From blackish mucus of the air-passages. α. Corpuscle having the same appearance as a young corpuscle of the blood; blood-red. β. Mass of blood-red discs; which had the appearance of an altered corpuscle of the blood. Such also was the appearance of γ, δ, ε, ζ. γ In outline: colour blood-red. This object was elliptical, and presented an orifice at one end; the orifice occupying the situation of the depression existing when the corpuscle had a discoid form. The object γ was composed of discs. δ, ε. Similar objects; but presenting numerous black points. Some of these black points are seen to have been in the centres of the discs, and others between the discs. The orifice was less distinct in ε; but there was a pellucid part in the same situation. ζ. Outline of a later state of the last-mentioned object.

Fig. 73. From the same mucus. α. Corpuscles, having the same appearance as young corpuscles of the blood. They were of the characteristic colour of blood-corpuscles, and exceedingly minute, but not the minutest seen; mere points having been observed in large number, of the same colour, and apparently derived from the same source. β. Outline of

similar corpuscles, arranging themselves into fibres, and then exhibiting indications of division into discs still more minute. γ. Outline of corpuscles of the same kind, arranging themselves into a cellular tissue-like object, and at the same time undergoing division into discs. β, γ. Blood-red.

Fig. 74. Tadpole of the large Toad of Jersey; about 6‴. α. Young blood-corpuscles; some of them exhibiting an orifice. Colour, pale red. β. Young blood-corpuscles of a deeper red.

Fig. 75. Tadpole, about 6‴. Blood-corpuscles; partly in outline. α. The minute red points around the nucleus in this corpuscle exhibited molecular motions. β. Discs are seen in the situation occupied by the minute red points in α; these discs pressed into polyhedral forms.

Fig. 76. Pale objects, composed of discs, from the blood of the same Tadpole. They correspond apparently to the "lymph-globules," or "corpuscles of the second form," of authors. α. The discs are numerous and minute. β. Discs fewer and larger. γ. The object in two portions,—perhaps a nucleus (eccentric), and an incipient cell; the nucleus composed of pale discs,—the surrounding part reddish. Discs were distinctly visible in this surrounding part also.

Fig. 77. Water Newt. Outline of blood-corpuscles, some of which were observed to contain blood-corpuscles, besides their nucleus.

Fig. 78. From the same. Objects found with blood-corpuscles,—all in outline except one. The latter, much enlarged, is seen to have been filled with, or made up of, discs; which was the case with all the rest. These objects appear to correspond to the "lymph-globules" of authors.

Fig. 79. From the same. Outline of a blood-corpuscle, and of the discs contained within it. The central object is the nucleus. (Acetic acid.)

Fig. 80. From the same. Outline of blood-corpuscles and their nuclei, as seen after the addition of an aqueous solution of nitrate of silver. The interior of one of the nuclei is shown. It was filled with discs, as were all the others.

Fig. 81. From the same. Outline of two blood-corpuscles, as viewed after the addition of a solution of corrosive sublimate. The interior of the nuclei is shown. α. In the nucleus were discs of about equal size. β. The nucleus presented discs at its central part; around which there was a space, apparently occupied by discs in a more advanced state and larger.

Fig. 82. Green Lizard. Corpuscles of the blood. α. Outline of one of these. β. Two corpuscles, the nuclei of which were composed of discs. γ. Corpuscle filled with discs. δ. Disc of the same colour as the corpuscles of the blood: perhaps a young corpuscle.

Fig. 83. Outline of blood-corpuscles from the egg of the Duck, incubated about 12 days.

Fig. 84. Blood-corpuscles, chiefly in outline, from the same egg. They are apparently in a stage more advanced than those in the preceding figure, with which, however, they were mixed. A nucleus, composed of discs, has been represented in some of these; and in one of the corpuscles, discs are seen surrounding the nucleus.

PLATE XXI.

Fig. 85. Tadpole, about 5‴. From the tail. Outline of epithelium-tables, having essentially the same appearance as blood-corpuscles circulating in the vessels of this larva. The peripheral portion of the six-sided tables resembled that of the object fig. 89.

Fig. 86. Tadpoles, about 5‴. Epithelium-tables, from the tail. α, β. Removed from the lacerated edge of the tail. α Is in outline. The form and size are here seen to have been very much the same as those of the blood-corpuscle in this larva. The same remark applies to the interior of this object, which is not shown in the figure. The envelope was also membranous. β. The germinal vesicle-like nucleus eccentric, and scarcely coloured: the discs on the nucleus, blood-red. The other objects in this figure were seen *in situ.* γ Resembled β, but it was membranous at the surface. δ, δ, ε, ζ, Resembled the ovum in their interior, and were blood-red at the surface.

Fig. 87. Tadpole, about 5‴. From the tail. Outline of the appearance presented by an epithelium-table undergoing division. (Dilute spirit.)

Fig. 88. Tadpole, 6‴. From the tail. Outline of three stages in the reproduction of epithelium-tables, having a situation corresponding to that of the large objects (centres) connected with pigment ramifications in figs. 90 and 91. The object on the left hand (in fig. 88.) represents the earliest, and that on the right the most advanced, of these three stages. These tables propagate by division, like every other disc. Each of the objects in this figure consisted of two parts; of which α was dark,—the other, β, colourless and pellucid. α. Oldest and largest tables; β, newest and smallest tables,—mere discs. In the centre of β, in the largest object, there was seen a part still more pellucid. β Is not in the centre of the object, but on one side. This corresponds with the situation of the most essential part in all other discs. In some instances, the number of parts into which objects such as those in the present figure were dividing, was observed to be four; this having been a stage still earlier.

Fig. 89. Tadpole, about $5'''$. Peripheral parts of several epithelium-tables, consisting of red discs, which (red discs) enter into the formation of the so-called ramifications of pigment (par. 118.). The central portion of the epithelium-tables here seen, appeared to be dividing into four parts, which, with a pale surrounding substance, are represented in outline only. From the tail.

Fig. 90. Tadpole, about $5'''$. A later stage of partitions (pigment ramifications) such as those in fig. 89, together with an object of a deep red colour, and an ovum-like interior. It is a centre for the origin of new epithelium-tables. From the tail.

Fig. 91. Tadpole, about $5\frac{1}{2}'''$. Appearance presented by portions of the choroid, arisen in the manner described in par. 118, as that in which the ramifications of black pigment in the epithelium of the tail have their origin. One of the objects is in outline. The so-called ramifications are really partitions; but not represented as such in the figure, which is intended to show no more than their appearance on a superficial view.

Fig. 92. Man. Objects from the surface of a furred tongue. α, β. Outline of epithelium-cells. Their contents, more or less red discs, which were reddest the nearer they were to the nucleus, excepting that in α the very red nucleus was surrounded by a more pellucid space, apparently occupied by larger discs. In β, the nucleus was very large; its pellucid nucleolus measuring as much as the nucleus of α. The nucleolus of β seemed to contain pale discs. γ. Outline of a mass of pale blood-red discs.

Fig. 93. Tadpoles, about $5'''$. Pigment of the eye, forming out of objects resembling corpuscles of the blood. The part marked ζ is that which had become the blackest. α. Four young blood-corpuscles, observed, along with others of the same kind, in the choroid. They had probably arisen in a manner analogous to that giving origin to the objects at α fig. 94. Three of these young corpuscles are in outline. They were composed of discs; and in the finished one, a pellucid nucleus was visible on one side. They were blood-red. β, γ. From the same part. β For the most part bright red, but approaching black in some parts. A nucleus visible in each,—distinctly in β, obscurely in γ. An orifice on one side in the nucleus of β. δ. An object somewhat resembling β. The nucleus excepted, it was blood-red. ε. Part of an object of the same kind as δ. ζ. Partitions between spaces, such as those occupied by δ and ε; at first sight appearing black, but, when more closely examined, found to be of a reddish colour. The discs of the bright red δ and ε undergo division, and are given off, to enter into the formation of the darker and blackish ζ. It appears that what is seen of ζ in the figure,

had been formed by portions previously given off in this manner from the centre δ. The object now described, on the right hand in the figure, was lying on the crystalline. I have seen similar objects in the choroid. The mode of origin of the partitions ζ, just described, is precisely analogous to that of the partitions in fig. 89, from the tail.

Fig. 94. Tadpole, about 6‴. α. Outline of a cell, filled with young epithelium-cells. This cell was red throughout. The cells which it contained, presented indications of further division, as seen by the one somewhat more finished, in delineation, than the rest. And at the left side, one of these young cells was broken down into cells or discoid objects of extreme minuteness. β. Two epithelium-cells, of a blood-red colour, except at the lower part, where they had become quite black. (Acetic acid.)

Fig. 95. Tadpole, about 6‴. Blood-corpuscles, apparently forming epithelium. All of these contained discs or incipient cells, which, generally speaking, had a deeper red, the nearer they were to the centre of the enlarging nucleus. The nucleus increased so as nearly to fill its corpuscle. In α, it consisted of a central portion, composed of four cell-like objects; and of two parts, concentrically arranged around these. β. The corpuscle is in outline. Four cell-like objects were seen within it, each of which was filled with discs. (Acetic acid.)

Fig. 96. Tadpole, 5‴. Epithelium-cell, having very much the appearance of an altered corpuscle of the blood. At β, it was nearly black; at most other parts, blood-red. Discs were seen, with more or less distinctness, at nearly all parts. At α, the surface was membranous; and internal to this portion of membrane, the substance was of a pale red, and free from the very highly refracting globules so numerous elsewhere in this object. At a certain part, is seen the nucleus; pale in colour, and in some degree pellucid. It presented discs.

Fig. 97. Tadpole, 5‴. An object entering into the formation of the epithelium, and for the most part blood-red. The eccentric nucleus exhibited a nucleolus, having apparently a peripheral situation. This nucleolus seemed to be an orifice, possibly communicating with the exterior. (Tincture of iodine.)

Fig. 98. Tadpole, about 5‴. Incipient epithelium-cylinders. Colour red, passing at the large extremity almost into black. Some of the discs composing the object α, were in motion, effecting changes in their form: and the object very slowly revolved on its axis, in the direction of the arrow. β. The same object, as viewed about half an hour after it presented the appearance at α. Its form was different. This may have arisen partly from a change in its direction,—the part which is pointed in β, having possibly been, in the condition α, directed towards the

observer. But it appeared that some alteration had really taken place in the form. A further change was noticed. The discs of the dark part in the condition α, were very indistinct. In the state β, they were well defined, and presented the appearance of little cylinders: which appearance was noticed also in the paler part of β. Motion not observed in the condition β. γ. State rather more advanced. The nucleus presented an orifice, having the appearance of a rent or fissure. The red colour was very deep. δ. Two of the appearances presented by a minute and isolated disc which was in motion,—changing its form and place.

Fig. 99. Tadpole, 5‴. An object, which was apparently an epithelium-cylinder, about to undergo longitudinal division. It contained two nuclei; one in a more advanced state than the other. Each of these was composed of discs, situated in concentric order around a space representing the nucleolus. This object was blood-red. (Tincture of iodine.)

Fig. 100. Tadpole, about 5‴. More advanced state of a corresponding object. The two nuclei pale. The surrounding part blood-red, passing nearly into black at some parts, especially at the lower end.

Fig. 101. Tadpole, about 5‴. Outline of portions of ciliary processes; the parts composing them having the same appearance as corpuscles of the blood.

Fig. 102. Duck. α. A cell observed lying among blood-corpuscles taken from the surface of the yelk, in an egg incubated five days. It had the same colour as the corpuscles of the blood. The membrane of this cell was of extreme delicacy. It contained a pale yellow substance, in which were globules, yellowish in colour, highly refracting light, and in vivid molecular motion. These motions were not observed when the cell was first seen; at which time, also, the contained globules were in closer approximation than the figure shows. Possibly the cell was ruptured while under examination. β. Similar globules, myriads of which were seen loose in the same field of view. Their molecular motion was most vivid, and attended with constant and considerable change of place.

Fig. 103. Tadpole, 4½‴. The larger object is a blood-corpuscle, and contents, for the most part in outline, very much enlarged. The interior presented globules resembling those of fat. These globules appeared to occupy the situation of the central part of what had previously been discs. Compare the disc α, and its centre, with apparently corresponding objects at β. The corpuscle exhibited redness at all parts, but chiefly on the side γ,—where, here and there, it was very dark,—though this appearance has not been at all represented in the figure. Something

like a nucleus was visible at δ. The smaller object is a blood-corpuscle of nearly the size usually met with. It also is, for the most part, in outline. It appeared to be an early state of such an object as the larger one. δ. Situation of the nucleus.

PLATE XXII.

Fig. 104. Ox (*Bos Taurus*, Linn.); fœtus of 5¼ inches. Nuclei of blood-corpuscles furnished with cilia, and changing their place. Colour blood-red. Two of them in outline. α. Observed in substance cut with scissors from the crystalline lens, while the lens was still imbedded in the vitreous humour; so that a portion of each may have been placed in the microscope. Two days had elapsed since the fœtus was taken from the body of its mother. β. Seen along with a portion of the retina and black pigment, from the other eye. The discs of this corpuscle appeared to shoot forth a process—the cilium—which then disappeared, as if drawn in. This corpuscle, as well as those at α, crawled about like an insect; but very slowly.

Fig. 105. Rabbit (*Lepus Cuniculus*, Linn.); killed two hours, *post coitum*. Blood-corpuscles and nuclei of blood-corpuscles observed in fluid taken from vessels in the immediate neighbourhood of a Graafian vesicle, which, from its size and vascularity, had evidently been destined to expel an ovum. α. A group of young blood-corpuscles. β. Outline of the nucleus of a corpuscle, one of the projections (altered discs) in which, appeared to be in motion. γ, γ, γ, γ. Four ciliated corpuscles,—or rather, ciliated nuclei of corpuscles,—of the blood. The cilia seem to be the filamentous extremities of discoid objects, into which the nucleus of the blood-corpuscle becomes divided. Objects such as those at γ, were seen very gradually to change their place; and others, of similar forms, were noticed to revolve; both of these effects seeming referable to their cilia. Examined eighteen hours after death. Among the corpuscles in this figure (and therefore apparently from the interior of a blood-vessel), were many objects of immeasurable minuteness, exhibiting molecular motions. These minuter objects had precisely the red colour of corpuscles of the blood, in which they probably had their origin (see par. 167.). δ. Outline of the nucleus of a blood-corpuscle, composed of discs not terminating in cilia, like those of γ.

Fig. 106. Common Fowl (*Phasianus Gallus*, Linn.); chick *in ovo*. Young blood-corpuscles observed in the immediate neighbourhood of the object fig. 116½. One of these is in outline. They were blood-red. These young blood-corpuscles, with others of the same kind, were in constant

motion; effecting a change of place (see par. 126.). Examined twenty-four hours after death.

Fig. 107. Ox; fœtus of eighteen inches. From the retina. Capillary vessels, forming out of corpuscles, having the same appearance as young corpuscles of the blood. These corpuscles, while still red (α), apply themselves together so as to form a necklace-like object, composed of elliptical beads: and having coalesced, and become pale (β), and the membranous partitions having disappeared, they form a tube. The corpuscles seem to apply themselves at certain parts in such a manner as to form a branched vessel. Resolving themselves (here, as well as when forming other tissues) into discs, the corpuscles contain within themselves the elements of new corpuscles. See α in the upper part of the figure. γ. Group of blood-corpuscles, and what seemed parts of blood-corpuscles (chiefly in outline), which may serve as a specimen of the many forms of these corpuscles, observed along with the foregoing. The central corpuscle in this group, resembles one of those marked β in fig. 63; where the nucleus of the blood-corpuscle is forming the pus-globule. (Blood-vessels seen forming in the same manner, and out of similar objects, in the retina of a chick; the egg incubated ten days.)

Fig. 108. Ox; fœtus of about seven inches. Outline of blood-corpuscles, observed among fibres from a muscle of the thigh. Most of these corpuscles were orange-shaped or globular, and exhibited an orifice. Some of them presented discs in their interior. The minutest objects in this figure were of the same colour as the larger ones,—blood-red.

Fig. 109. Ox; fœtus of about seven inches. Corpuscles having the same appearance as blood-corpuscles, observed among fibres from a muscle of the thigh. They appeared to be passing into the elements of cellular tissue. α. The corpuscle has one large orifice. β, β, β, β, β. It exhibits two or more small orifices. γ. The corpuscle has passed into a mass of discs; this mass being, not cylindrical, but flattened. In such objects as β and γ, the outline of discs is hidden, apparently, by red colouring matter.

Fig. 110. From the same. Altered corpuscle, having the same appearance as a corpuscle of the blood. It had become a mass of discs resembling those marked γ in fig. 109, but terminated at each extremity in a fibre; thus presenting a more advanced stage in the formation of cellular tissue.

Fig. 111. Ox; fœtus of about five inches. Altered corpuscles having the same appearance as blood-corpuscles, passing into cellular tissue. The filaments into which the corpuscles are prolonged, consist of coalesced discs. Colour quite red. Taken from under the superficial muscles of the neck.

Fig. 112. Ox; fœtus of five inches. From the axilla. Three altered corpuscles having the same appearance as corpuscles of the blood. α. Many bright points seen (par. 134.). β. Discs now visible. γ. Some of the discs have enlarged, while others have divided into smaller discs, which are coalescing, and thus entering into the formation of the filaments of cellular tissue, with the elements in themselves of further perpetuation. This corpuscle (γ) was bent, from its position in relation to β. (Tartaric acid.)

Fig. 113. Ox; fœtus of five inches. Altered corpuscle having the same appearance as a blood-corpuscle, passing into cellular tissue. (Transition unequivocal.) From the axilla. (Citric acid.)

Fig. 114. Rabbit; killed two hours *post coitum.* From the fimbriated extremity of the Fallopian tube. Cellular tissue, forming out of altered corpuscles having the same appearance as corpuscles of the blood.

Fig. 115. Tadpole, about 6‴. Outline of altered corpuscles having the same appearance as corpuscles of the blood. They are composed of discs, entering into the formation of cellular tissue. All the objects were pale red; and the transition out of corpuscles having the same appearance as unaltered blood-corpuscles was observed.

Fig. 116. Tadpole, 5‴. Outline of incipient cellular tissue, composed of discs. It was forming out of corpuscles having the same appearance as corpuscles of the blood; and still red. This cellular tissue lay around the spinal chord, at a part where the latter had a diameter of $\frac{1}{20}$‴; being apparently in the course of forming the sheath of the spinal chord. α. The outer part of this cellular tissue. β. A part of the sheath more internal; consisting of minuter discs. (Acetic acid.)

Fig. 116½. Common Fowl; chick *in ovo.* Outline of what seemed to be the foundation of two portions of cartilage in the wing, in an extremely early stage (par. 145.). These were composed of very large cells, filled with other cells. Colour pale red. The large cells had the appearance of altered blood-corpuscles. α. Some of the inner cells are seen; β, none but the outer cells. The nuclei of the inner cells in α were blood-red, and not distinguishable from the young blood-corpuscles fig. 106, lying near. (Some of the nuclei of the inner cells in β presented the same appearance; while others were larger and paler.)

Fig. 117. Tadpole, 5‴. Portion of the foundation of a cranial vertebra, composed of corpuscles having the appearance of more or less altered corpuscles of the blood. The round objects are the *nuclei* of the corpuscles. Two of the entire (elliptical) corpuscles are seen of an unaltered shape. All in outline except two of the nuclei. All the nuclei filled with discs.

Fig. 118. Tadpole, 6‴. Cells entering into the formation of cartilage, apparently

part of the foundation of the orbit. They are in outline only; the nuclei rather more finished. The latter presented discs. α. The cell contained two nuclei, besides discoid objects. The former and a few of the latter are represented in the figure. These discoid objects probably resulted from decomposition of the outer part of one of the nuclei,—thus rendered smaller than the other. (The contents of the other cells are not represented in the figure.) (Essentially the same state observed in the foundation of a vertebra, in a Tadpole of 7‴.)

Fig. 119. Common Fowl; chick *in ovo*, on the tenth day of incubation. Elements of cartilage. (Foundation of a bone—diameter $\frac{1}{7}$‴—in one of the lower extremities.) Partly in outline. Red colouring matter still present in the objects β; which, however, were paler than the objects α. Those at β formed a dense mass. (Portions of incipient vertebræ seen in a similar state from the same chick (fig. 122.); substance also from the extremity of a duck's bill, and from its claw (thirteenth day of incubation), observed to be in essentially the same state, and with a corresponding transition out of corpuscles, having the same appearance as corpuscles of the blood.)

Fig. 120. From the same object as fig. 119. Appearance, chiefly in outline, of the marginal portion.

Fig. 121. Tadpole, 5‴. Portion of the cartilaginous foundation of one of the orbits; composed of the nuclei of corpuscles, resembling corpuscles of the blood. Colour red.

Fig. 122. Objects from the foundation of a transverse process of one of the vertebræ in the chick from which fig. 119. was taken. α. Blood-red corpuscles composed of two or three discs. They resembled altered young blood-corpuscles. These appeared to be entering into the formation of the cortical portion of the transverse process, in which objects such as those at β occupied a less superficial place.

PLATE XXIII.

Fig. 123. Tadpole, 4½‴. Outline of corpuscles having essentially the same appearance as blood-corpuscles, collected to form the optic nerve. Taken from a part of the nerve, just before its entrance into the eye-ball, which part measured in diameter about $\frac{1}{20}$‴. One of the corpuscles is not merely in outline; the peripheral part being represented in a more finished state. The central portion however—nucleus—is not shown. At the periphery are seen minute, highly refracting, red discs, dividing into minuter discs. The nerve did not present any fibres, the corpuscles being merely in contact with one another. In another instance, where

the part was more advanced, the surrounding globules had very much disappeared; and the corpuscles were in polyhedral forms.

Fig. 124. Tadpole, about 5‴. Corpuscles having precisely the same appearance as blood-corpuscles, passing into the elements of the optic nerve. Taken from various parts of a fasciculus of incipient fibres in the immediate neighbourhood of the eye-ball, which the fasciculus was seen to enter. *α*. The corpuscles in question arranging themselves in a line. These are all in outline except one. Immediately within their membrane was red colouring matter. This surrounded a pale globular object (nucleus), in which were discs. In the red colouring matter, there were seen very minute globules, having a high refracting power. These were of a brilliant red colour. Many of them appeared to be undergoing division. They presented the appearance of a rose. These globules occupy the situation of such as are seen, in many instances, to exhibit molecular motions in corpuscles of the blood.—All the other objects in the figure were composed of discs; and all were red, the colour becoming paler in the more advanced.

Fig. 125. Tadpole, about 7‴. Portions of the optic nerve, forming out of corpuscles having the same appearance as corpuscles of the blood. Quite red. Almost entirely in outline. *α*. The discs into which the nuclei of the said corpuscles had passed, were arranging themselves in something like lines; and they presented discs in their interior, as in the more finished disc of this object. *β*. From a part of the same nerve, more advanced. This object is a tube, at the periphery of which there were seen discs coalescing. These discs presented discs in their interior, corresponding apparently to the minutest of those in the object *α*. Pellucid points, apparently orifices, were seen here and there; and they seemed to communicate with the exterior of the incipient tube. (Dilute spirit.)

Fig. 126. Ox; fœtus of eighteen inches. From the retina. Two corpuscles having the same appearance as corpuscles of the blood. *α*. But little changed. *β*. Orange-shaped; a large orifice in the situation of the original depression (which existed when the corpuscle was a disc). Two pellucid points on one side (par. 154.). (Dilute spirit.)

Fig. 127. Ox; fœtus of ten inches. From the retina. Two altered corpuscles having the same appearance as corpuscles of the blood. *α*. The orifice is very large; but single. *β*. There exist two orifices (par. 154.).

Fig. 128. Sheep (*Ovis Aries*, Linn.); fœtus of eight inches. Corpuscles having the same appearance as corpuscles of the blood, passing into globules for the formation of the retina. See the description of fig. 130; the letters denoting similar objects in both figures.

Fig. 129. Ox; fœtus of eighteen or twenty inches. Objects from the retina, as seen after the addition of acetic acid. (See the description of the following figure.)

Fig. 130. From the same fœtus. Elements of the retina, formed of corpuscles, having the same appearance as corpuscles of the blood. α, β, γ, Are such corpuscles, passing into globules. α. They have undergone but little change. β. Two or more pellucid points are seen in each corpuscle (par. 154.). γ. The globule is now seen to be composed of discs. δ. A cell, the nucleus of which consists of several discs. ε. Cell rather larger than that at δ. Its nucleus, which had a similar appearance, is in outline. ζ. Cell, the nucleus of which was surrounded by a space more pellucid than the rest of the cavity of the cell. The whole in outline. η. Cell, in the nucleus of which are seen five discs. The cavity or depression in one of these was very large; and probably indicated the situation of the orifice in the membrane of the cell. θ. Very large cell. Its nucleus consisted of two parts. One of these was dark, and globular in form. The other part surrounded that just mentioned, and consisted of many globules. Each of the globules (in both parts) was composed of discs, which were circumscribed by a delicate membrane. The whole nucleus, also, was similarly circumscribed. ι. Spindle-shaped object, composed of discs, possibly representing an altered state of a globule such as γ,—the first change being seen at κ. When passing into the elements of the retina, corpuscles having the same appearance as corpuscles of the blood seem to continue longer of a flattened form than is usual elsewhere; γ, for instance, being rather orange-shaped than globular. All the nuclei (δ, ε, ζ, η) were circumscribed by a delicate membrane.

Fig. 131. Tadpole, $4\frac{1}{2}'''$. Objects derived from corpuscles having the same appearance as corpuscles of the blood, entering into the formation of the elements of the retina. (The transition observed, though not represented in the figure.)

Fig. 132. Tadpole, about $5\frac{1}{2}'''$. Outline of corpuscles having the same appearance as slightly altered corpuscles of the blood; as seen entering into the formation of the spinal chord. In one of these corpuscles, are delineated the objects which were seen surrounding the nucleus. (Dilute spirit.)

Fig. 133. Ox; fœtus of $5\frac{1}{4}$ inches. From the cortical portion of the brain, in which objects such as those in the figure were observed in large numbers,—often seen to be flattish in their form. They were all more or less red, some blood-red, the difference being in some degree represented by the shading; all were either discs themselves, or composed of discs; and

all were either corpuscles themselves, having the same appearance as blood-corpuscles, or immediately derived from such corpuscles. The less advanced of these objects had the same appearance as young blood-corpuscles; these passing into the objects more forward. α, β, γ, δ, Presented exactly the same appearance as young corpuscles of the blood. α Becoming orange-shaped,—blood-red; β, nearly globular,—an orifice in the situation of the original depression presented by the corpuscle when discoid in form: paler, yet blood-red. γ. Discs visible, yet indistinctly, from the presence of red colouring matter. Dark blood-red. δ. Paler, yet still blood-red. ε Resembles δ, but is more advanced,—being paler, and the discs being more distinct. ζ. Two sets of discs, an inner and an outer; the inner, deep red,—the outer, pale red. This seems to correspond to ε more advanced; the inner discs of ζ occupying the situation of the pellucid centre of ε. η, η. Three concentric parts,—namely, first, an outer part, consisting of pale and nearly colourless discs—this being the oldest part of the corpuscle;—secondly, a middle part, composed of blood-red discs (obscured in one, distinct in the other),—this part being the next in age;—thirdly, a central, round, blood-red object, pellucid in its middle, which is the newest part. θ. A mass of blood-red discs.

Fig. 134. Objects from the medullary portion of the brain in the same calf; observed along with such as those in the preceding figure. The same general remark as that in the explanation of fig. 133, respecting discs, form, colour, and origin in corpuscles having the same appearance as blood-corpuscles, is applicable here. α, β. Young blood-corpuscles; both blood-red. β Is passing into discs. γ. Mass of quite red discs. δ. The outer discs almost colourless; the middle set, as well as the central part, still red. Compare with η, η of fig. 133, of which δ in the present figure seems to be a more advanced state. The pellucid object in its central part, more defined. (Compare with the remarks in the explanation of fig. 43 β in Part II.) ε. Discoid, and very pale; yet reddish. These objects were present in large numbers, and contained discs themselves. They resemble in some degree the corpuscles from which they are derived. Not generally seen in rows.

Fig. 135. Common Fowl; chick *in ovo*. From the leg. Cells having the appearance of altered young corpuscles of the blood. Quite as red as blood. α. Outline of some of these arranging themselves to form muscle. β. Another, exhibiting the internal state. It was filled with discs;—outer part of the nucleus, a layer of very minute discs. The inner part of the nucleus consisted of finely granular substance. Centre, an orifice (par. 161.). (Dilute spirit.)

Fig. 136. Same chick. Outline of corresponding cells, from the same part, and in a more advanced state. The nuclei presented indications of division into discs (par. 161.). (Dilute spirit.)

Fig. 137. From the leg of the same chick. Outline of a muscle-cylinder, containing discs, a few of which are represented in the figure. The partitions between the original cells which form the cylinder, have disappeared. The nuclei were parietal, and composed of discs. The nucleus finished in delineation, exhibits these discs in concentric layers, around an orifice, communicating with the exterior of the cylinder (par. 161.). (Dilute spirit.)

Fig. 138. Tadpole, $5'''$. Outline of part of the foundation of the crystalline lens, as it lay surrounded by black pigment, and imbedded in the vitreous humour. It had the appearance of an altered and greatly enlarged blood-corpuscle; being throughout red,—except at α (the anterior part), where it was pellucid,—and being filled with discs resembling those arising in the interior of a corpuscle of the blood. These discs were largest and darkest at the part β.

Fig. 139. Tadpole, about $5'''$. Outline of cells forming a portion of the crystalline lens. They were very pale, yet tinged with red. Red colouring matter was seen between the cells. The interior of all these cells presented discs; and here also was observed red colouring matter. The cell, the interior of which has been delineated in the figure, was brighter than the rest, and its discs were more defined. On being viewed repeatedly, for a considerable time, the appearance of the interior of this cell was found to vary, *apparently from the discs changing their position.* This cell possibly corresponded to the central cell in fig. 140.—(Surrounding the incipient lens, there was forming a membrane,—perhaps the membrane of the lens. It seemed forming by the coalescence of objects, redder and less pale than those in the present figure; and in just the same manner as the membrane of the ovisac (fig. 172.). The crystalline and its membrane may perhaps arise, like the ovum and its ovisac, from a *single* corpuscle having the same appearance as a corpuscle of the blood (par. 181.)).

Fig. 140. Tadpole, about $5'''$. Appearance of a part, probably the centre, of the crystalline lens; the lens measuring in diameter $\frac{1}{20}'''$. The object α was dark red; the branched substance around it, very pale, yet reddish. The latter extended, in the same branched form, to the edge of the lens.

Fig. 141. Sheep; fœtus of eight inches. Objects observed in a portion of the crystalline lens, cut with scissors from the surface. The field of view presented a large number of capillary vessels, having a diameter of $\frac{1}{600}'''$

to $\frac{1}{100}'''$, and filled with red blood. One of the minutest is seen at α. The corpuscles in it were pressed into irregular forms. α, α. Some of the same vessels, in outline. β. Corpuscle of the blood, filled with young corpuscles; these being mere discs, elliptical, and differing from other discs only in being redder. γ. Outline of two of the same parent-corpuscles, which were filled, in like manner, with young corpuscles; their membranes shrivelled. δ. Parent-corpuscles of the blood, ruptured, and from which young corpuscles were escaping. Some of the latter were still elliptical; while others had become round, but continued flat. ε. Young blood-corpuscles, larger than those at δ.

PLATE XXIV.

Fig. 142. Ox; fœtus of ten inches. From the posterior surface of the crystalline lens. Vessels here radiated from central trunks, towards the margin of the lens. On the left hand in the figure, are three corpuscles having the appearance of much altered corpuscles of the blood. A few blood-corpuscles have been represented in the portion of vessel figured. It contained many not here shown. Most of the corpuscles figured, as well as the vessel itself, are in outline. α. Young blood-corpuscles, still elliptical, mere discs, and red. β. Blood-corpuscle in nearly the usual state. γ. Form altered, but the corpuscle still quite red. δ. Blood-corpuscles dividing into discs, and of a paler red. ε. This division of the blood-corpuscle into discs, has proceeded farther; and the effects are seen of the same process as that which forms cellular tissue (par. 134.). ζ. Pale discs, derived from blood-corpuscles. η. Corpuscle having the appearance of an altered corpuscle of the blood. It consisted for the most part of pale red discs. Two of the discs presented by this corpuscle, were of a deeper red, and had a darker outline. These occupied the situation of the original orifice, and afford a remarkable instance of the identity of the process effecting changes in corpuscles, having the same appearance as blood-corpuscles, with that producing the first alterations, *post coitum*, in the mammiferous ovum; and also of the similarity between the changes producing pus-globules, and some other objects. θ. Corpuscle, having the appearance of a blood-corpuscle very much enlarged. It was colourless and brilliantly pellucid in the situation of the original orifice; and at the part surrounding this, the corpuscle was blood-red, presenting indications of the formation there of discs. ι. Similar state of a corpuscle of smaller size.

Fig. 143. Common Fowl; chick *in ovo*. Corpuscle in a state analogous to that of β. fig. 155. and of θ and ι, fig. 142; and also having the appearance of an altered blood-corpuscle. It was observed, along with many others, having a similar condition, in the neighbourhood of the crystalline lens. Shreds also were seen, composed of corpuscles in the same state.

Fig. 144. Ox; fœtus of eighteen inches. From the edge of the crystalline. Portion of a tube filled with corpuscles having the same appearance as young corpuscles of the blood. A few of these are represented in the figure. Where shaded, the corpuscles were red; where the corpuscles are in outline, the red colouring matter had disappeared. They were mere discs. α. The corpuscle was red in the centre (the situation of the original cavity or depression), and colourless in the surrounding part.

Fig. 145. Sheep; fœtus of six inches. From the edge of the crystalline lens. Portion of a flattish tube, filled with corpuscles having the same appearance as corpuscles of the blood. These corpuscles, most of which are represented in outline only, were arranged with great regularity; their flat surfaces being in contact with one another. They were blood-red, and red colouring matter was seen between or around them.

Fig. 146. Another part of the same tube, filled in a like manner, but much smaller in diameter, and exhibiting a space unoccupied by corpuscles. The membrane of the tube very delicate.

Fig. 147. Another portion of the same tube. The corpuscles exhibited a brilliantly pellucid object in the situation of their original cavity or depression; their external part being still red.

Fig. 148. Twisted portion of a tube of the same kind, and from a similar locality in the crystalline lens of the same fœtus. The corpuscles were red, and in a state which in other respects, also, was similar to that of the corpuscles in fig. 147.

Fig. 149. Ox; fœtus of eighteen inches. From the edge of the crystalline lens. Portion of a tube filled with corpuscles having the appearance of blood-corpuscles in a more or less altered state. These are in outline only. Some were round; others elliptical. Most of them exhibited traces of division into discs, which in two instances have been represented in the figure. Here and there, these corpuscles were still blood-red; but the most advanced of them had become pale.

Fig. 150. Ox; fœtus of eighteen inches. From the edge of the crystalline lens. Portion of a tube filled with corpuscles having the appearance of more or less altered blood-corpuscles. Those on the side α were blood-red; while those on the side β had become pale. The latter were also elongated, and dividing into discs. In some parts, the corpuscles seemed to be arranging themselves in lines, as.if to form fibres.

Fig. 151. Sheep; fœtus of six inches. From the edge of the crystalline lens. Portion of the tube filled with corpuscles having the appearance of altered and enlarged blood-corpuscles. In outline. These corpuscles exhibited a brilliantly pellucid object in the situation of the original cavity or depression. In some instances, this pellucid object seemed double. The surrounding part of the corpuscles was blood-red.

Fig. 152. Ox; fœtus of eighteen inches. From the edge of the crystalline lens. Portion of a tube filled with corpuscles having the appearance of blood-corpuscles in greatly enlarged and altered states. (See the description of fig. 142.) α, β. Several of the many pellucid spaces, occupying the situation, apparently, of the original cavity or depression in the corpuscles. Some of these spaces were very minute; and others, β, so large, that they seemed to have resulted from the coalescence of several smaller ones. By degrees, indeed, the tube may thus become colourless in its whole diameter; the red colouring matter, γ (which is situated between the pellucid spaces), having disappeared. The figure, which is chiefly in outline, represents the red colouring matter only at the upper part (γ); where a trace is seen of the division between the corpuscles. δ. There is visible in some of the pellucid spaces, a minute, highly refracting object, apparently an orifice, which at δ, δ, seemed to communicate with the exterior of the tube. ε. Outline of corpuscles having the same appearance as young corpuscles of the blood, observed with the foregoing. One of these, it will be seen, did not exceed $\frac{1}{800}'''$ in length.

Fig. 153. Sheep; fœtus of six inches. From the crystalline lens. Outline of pale cells. One of them was seen to be filled with discs, which also are represented in outline.

Fig. 154. Ox; fœtus of ten inches. From the crystalline lens. Pale cells, for the most part in very early stages of formation, and exceedingly minute. The cells are in outline, except their nuclei, a few only of which (nuclei) have been delineated. In many of the cells, however, a nucleus was not discerned. And this indeed was in most instances the case. α. Objects composed of discs. The outer portion (exceedingly minute discs) of such objects appears to separate from the rest, to form the membrane of a cell; the remainder being the nucleus of the cell. β. The cell-membrane formed. γ. Nucleated cells more advanced. The other cells in this figure are in outline. Some of them, δ, are arranged in rows; which was observed in many instances to be the case. Cells even of the minuteness of those in this figure, often seem to contain discoid objects; especially if the nucleus has disappeared.

Fig. 155. Ox; fœtus of eighteen inches. From the edge of the crystalline lens.

Corpuscles, having the same appearance as corpuscles of the blood, passing into pale cells,—the elements of the crystalline. α. Outline of two of these corpuscles, which were but little changed. Their contour was irregular. Corpuscles in such states, when required to pass through a minute space, undergo remarkable alterations in their form, and are seen to be susceptible of extreme attenuation. β. Composed of discs. Two brilliantly pellucid orifices are seen on one side; this being the situation of the originally single orifice in the corpuscle or disc, before its division into other discs. This is the situation, also, of the nucleus of the future cell, if formed. γ. Flattish corpuscle, composed of discs, and blood-red. δ, δ. Corpuscles resembling γ, but larger, and in little more than outline. ε, ε. Nucleated cells. The nuclei are dividing into discs. ζ. An orifice in the nucleus, apparently communicating with the exterior of the cell. This orifice would have been the situation of the future nucleus, after the division of the present one into discs; which discs were already formed, but not separated. η. Besides a nucleus, consisting of discs, the cell exhibits discs in its cavity. Only two of these are represented in the drawing. All the objects in this figure presented red colouring matter; which in α, β, γ, δ pervaded the entire object; but in ε, ζ, and η, was confined to the nucleus.

Fig. 156. Ox; fœtus of ten inches. From the crystalline lens. Outline of cells, the elements of the crystalline, for the most part exceedingly pale. They were altered corpuscles having the same appearance as corpuscles of the blood; and presented states which, in general (not in every instance), were more advanced than those in fig. 155. α. The contour irregular, from the incomplete formation of the membrane, which discs were coalescing to produce. The dark round object is the future nucleus. In it is an orifice, communicating with the still incipient cell. This orifice indicates the situation of a future nucleus, to form as the existing one divides into discs. β. A state resembling α, but the nucleus already composed of discs. γ. The nucleus has divided into two portions, each of which consists of incipient discs. δ, δ. A nucleus not visible. But the interior of the cell presented discs; too indistinctly, however, to admit of delineation. Such was the case also with the cell γ.

PLATE XXV.

Fig. 157. Ox; fœtus of ten inches. From the crystalline lens. Incipient fibres, forming by the coalescence of cells of the same kind as some of those in figs. 153, 154, 155, 156; which are derived from corpuscles having

the same appearance as corpuscles of the blood. These incipient fibres are in outline. α. An orifice in the nucleus, probably communicating with the exterior of the cell. One part of the fibre β still presented a bead-like appearance. In another part, the cells had fully coalesced into a cylinder. The latter was the case throughout the fibres γ. In some of these latter fibres, peripheral objects were still seen (par. 178.). δ. A cell filled with discs; a nucleus not being observed in this cell.

Fig. 158. From the same crystalline lens. Outline of incipient fibres. See the description of the preceding figure. α. An orifice in the nucleus, communicating with the exterior of the cell. Nuclei were not observed in any of the cells at the upper part of this figure; the cause being probably that these cells were more advanced than those in the lower line, and that their nuclei had been divided into the contents of the cells. β. Deficiency in the size of the cells, made up for by the number present in the diameter of the fibre.

Fig. 159. From the crystalline lens of the opposite eye in the same fœtus. Cells such as those in the two preceding figures,—but, generally speaking, larger—arranging themselves to form a fibre of the crystalline. Some of these cells presented a nucleus. In others, no nucleus was seen. The nucleus, as elsewhere, appeared to be composed of discs. The nucleus on the left consisted of two discs; and each of these presented indications of a subdivision into minuter discs. Two of the cells entering into the formation of the fibre in this figure, were very minute compared with the rest.

Fig. 160. Stone-chat (*Motacilla rubicola*, Linn.). From the testis, after maceration for a night in water. Altered corpuscles having the appearance of blood-corpuscles. They were blood-red, consisted of discs, and were apparently progressing to form fasciculi of spermatozoa. The smallest is in outline.

Fig. 161. Yellow Bunting (*Emberiza citrinella*, Linn.). From the testis. Altered corpuscle having the appearance of a blood-corpuscle, composed of discs which were deep red; and apparently in the course of forming a fasciculus of spermatozoa.

Fig. 161½. Rabbit; killed two hours *post coitum*. From the vagina. α. Several spermatozoa, apparently composed of discs, the number of which discs appeared greater in some than in others. β. An object composed of discs. On the left, this object presented a part much darker than the rest, apparently an orifice, in which the discs were seen with great distinctness. γ. Outline of an object of the same kind, but smaller. The darker part obviously communicated with the exterior by an orifice, γ γ, in which the discs were exceedingly distinct, as well as at the

part circumscribed by a dotted line; the latter part being continued from the orifice (γ γ,) to the centre of the object γ, and brought into view by depressing the instrument. δ. A larger object, being either an advanced state of β and γ, or else containing several objects such as these. δ Seemed to be composed of discs, among which were seen some with caudal appendages,—probably spermatozoa. δ Was circumscribed by a membrane. (Acetic acid.)

Fig. 162. Stone-chat. Objects from the testis; namely, α, altered corpuscles having the same appearance as corpuscles of the blood,—and β, γ, δ, portions of spermatozoa, forming out of such altered corpuscles. Red colouring matter visible in all. The corpuscles composed of discs. β. Part of two spermatozoa, in the course of formation out of discs. γ. Discs which appeared to have coalesced at their extremities and sides. At the upper part, and on the left side, of this object, is seen a partially formed spermatozoon. It would thus seem that the spermatozoa are here formed by division of the discs; and this mode of origin is no doubt connected with their spiral form. δ. Portion of a spermatozoon completely formed.

Fig. 163. From the testis of the same Bird, after a night's maceration in water. α. The large corkscrew-like extremity of a spermatozoon. β. Outline of two similar objects, the position of which, in relation to each other, was such as to suggest the idea that the division of the discs, for the formation of the spermatozoa, was either incomplete, or so recent that the spermatozoa were still imperfect; and that their position had not changed. The objects in this figure were blood-red.

In the figures of the ovum (figs. 164 to 173.) the letter *c* denotes the germinal vesicle, *g* the discs of the ovisac, and *h* the membrane of the ovisac†.

Fig. 164. Wryneck (*Yunx Torquilla*, Linn.). Corpuscle having the same appearance as a blood-corpuscle, very much enlarged, and filled with young corpuscles. Each of these young corpuscles is an ovum (including the ovisac) in a rudimental form. These objects are for the most part in outline; but three of them are in a more finished state. *g*. Discs, into which a portion of the young corpuscle has divided. In some parts these discs were quite red; in others pale. *c*. Germinal vesicle, in the situation of the original depression existing in the young corpuscle, when the latter was a disc. In the young corpuscle on the right, *c* is still a mere disc, having a diameter of $\frac{1}{700}'''$. At a certain part, the membrane of *c* presents an orifice, indicating the situation of the future germinal spot. (Acetic acid.)

Fig. 165. From the same ovary. Corpuscles having the same appearance as young

blood-corpuscles, forming ova. They differed from the objects of the preceding figure in retaining more the appearance of *discs*; the transition from which is here very obvious,—α having apparently undergone no further perceptible change than that of becoming round. β. The outer portion now consists of discs,—the inner part being itself a disc, the future germinal vesicle. γ. A more advanced state; the part *c*, corresponding to the central disc of β, being now the germinal vesicle. In the object not marked, two discs seemed to occupy the situation of *c* in γ. (Acetic acid.)

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† The same letters are here used, and they denote the same objects, as in my memoirs on Embryology, *ll. c.*

Fig. 166. From the same ovary. Part of a group of corpuscles having the same appearance as young blood-corpuscles, just escaped from a parent corpuscle, such as that in fig. 164. They were blood-red, and appeared to be membranous at the surface. These objects are rudimental ova. The letters as above. A distinct orifice in *c*. (Acetic acid.)

Fig. 167. From the same ovary. Part of a group of objects of the same kind, colour, origin, and general appearance, except that they were not membranous at the surface. One of the germinal vesicles, *c*, is larger than the rest; and the orifice in it is of considerable size. (Acetic acid.)

Fig. 168. From the same ovary. State of the rudimental ovum (altered corpuscle having the same appearance as a blood-corpuscle) rather more advanced. The germinal vesicle (*c*) was larger, and the discs *g* were dividing into minuter discs. These discs were quite red. (In one instance, in which the size of the rudimental ovum was about the same, the discs *g* had begun to coalesce for the formation of the membrane of the ovisac.) (Acetic acid.)

Fig. 169. From the ovary of the same Bird. Conditions which, excepting α, are still more advanced. α. Still blood-red. β. In outline. Redness diminished. Globules between the discs. γ. Chiefly in outline. Each of the discs presented a cell-like object in the situation of its original depression. δ. Blood-red. The discs *g* dividing into smaller discs. The germinal vesicle (*c*) obscurely seen in the interior.

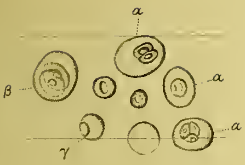
Fig. 170. From the ovary of the same Bird. Portion of an ovisac, elliptical in form, and $\frac{1}{40}'''$ in length. Partly in outline. *h*. Membrane of the ovisac, forming out of the discs *g*, which for this purpose are dividing into minuter discs. *g*. Quite red, and becoming pale in *h*. *c*. Portion of the germinal vesicle.

Fig. 171. From the same ovary. Similar objects in a more advanced state. Length of the ovisac $\frac{1}{20}'''$. The discs *g*, within the ovisac, were smaller than those in fig. 170; having undergone division. Where lying around the germinal vesicle (*c*), they were smallest, had a high refracting power, and were quite red. Proceeding from this situation towards the membrane, *h*, of the ovisac, we find them increasing in size, losing their high refracting power, and becoming pale. Where entering into the formation of the membrane *h*, they were largest, and undergoing a further division. Even the outermost of these discs *g*—those coalescing to form *h*—though very pale, presented a tinge of red.

Fig. 172. From the same ovary. Portion of the membrane of an ovisac, which was elliptical, and $\frac{1}{3}'''$ in length, as it lay crushed under a piece of glass. It still presented a pale tinge of red, as well as traces of some of the discs of which this membrane is composed.

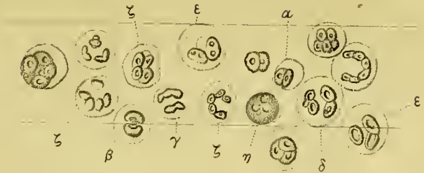
Fig. 173. Canary bird (*Fringilla Canaria*, Linn.). Part of an ovisac ($\frac{1}{30}'''$ in diameter), with its contents; the whole derived from a corpuscle having the same appearance as a corpuscle of the blood, and the whole still more or less red. Respecting *g* and *h*, see the explanation of the preceding figures. (The figure does not represent the membrane of the yelk.) *c*. Germinal vesicle, containing reddish discs; the minuter of which surround a central disc, which is the newest solid part. In the centre of the latter there is a dark point, representing (by refraction) a fluid space,—the situation of the future germinal spot.

Corpuscles of the Blood.



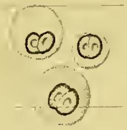
24

Fœtal Ox, ¾ Inch.



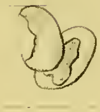
23

Man. — Acetic Acid.



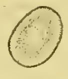
27

Fœtal Ox, ¾ Inch.
Acetic Acid.



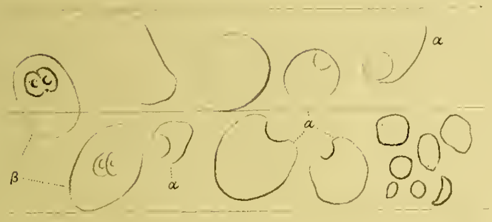
25

Fœtal Ox. ¾ Inch.
Incipient Collapse.



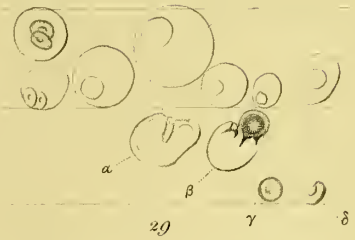
26

Fœtal Ox, ¾ Inch.



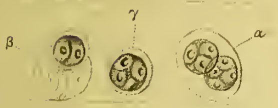
28

Fœtal Ox, 1 Inch.



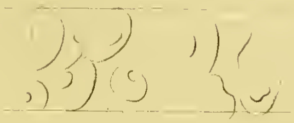
29

Fœtal Ox. 1 Inch — Acetic Acid.



30

Fœtal Ox, 1¼ Inch.
Acetic Acid.

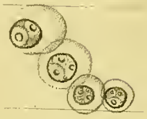


31

Fœtal Ox, 1¾ Inch.
Acetic Acid.

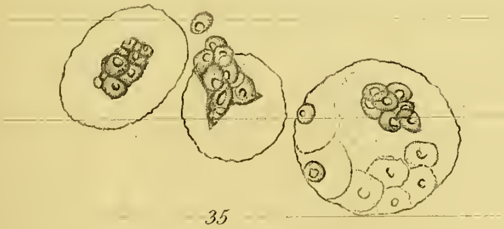
32

Fœtal Ox,
1¾ Inch.



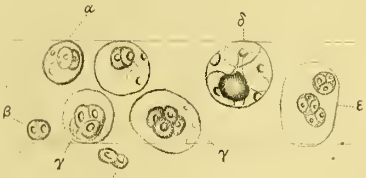
33

Fœtal Sheep. 2½ Inches.
Acetic Acid.



35

Fœtal Ox, 1¾ Inch. — Liver.
Acetic Acid



34

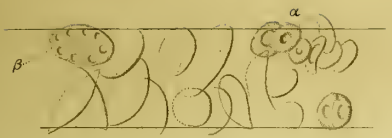
Fœtal Ox, 1¾ Inch.
Acetic Acid.

All the objects are seen of their relative sizes, being alike magnified 600 diameters. Their actual sizes may be determined by reference to the spaces they occupy between the horizontal lines, which are $\frac{1}{100}$th of a Paris line apart in the micrometer itself. Thus in Fig. 29. the actual diameter of γ is $\frac{1}{300}$''' (Paris Line.)

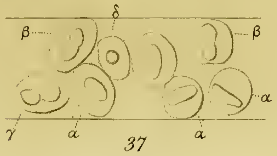
Ad. Nat. del. Martin Barry.

J. Basire. sculp.

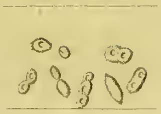
Corpuscles of the Blood.



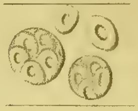
36
Sparrow.



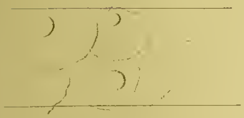
37
Sparrow.
Acetic Acid.



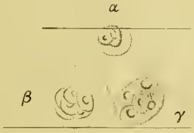
38
Sparrow.
Acetic Acid.



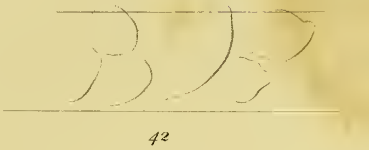
39
Sparrow.
Acetic Acid.



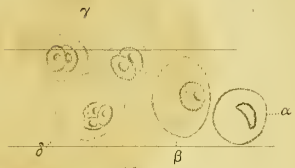
40
Chick in ovo.
80 Hours.



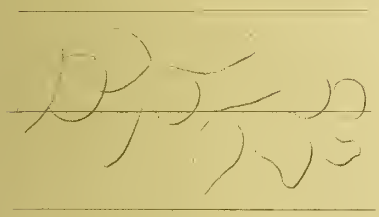
41
Chick in ovo.
80 Hours_Acetic Acid.



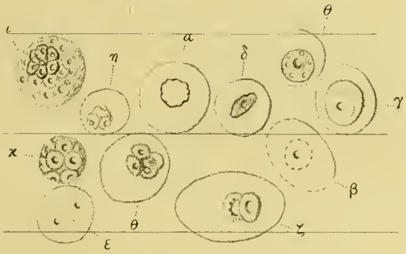
42
Chick in ovo.
85 Hours.



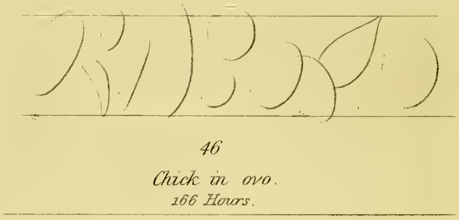
43
Chick in ovo.
85 Hours_Acetic Acid.



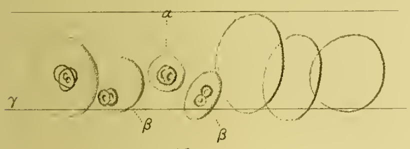
44
Chick in ovo.
92 Hours.



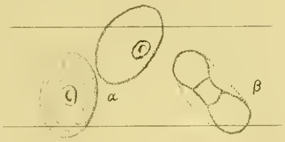
45
Chick in ovo.
92 Hours_Acetic Acid.



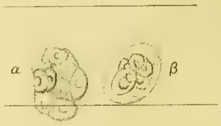
46
Chick in ovo.
166 Hours.



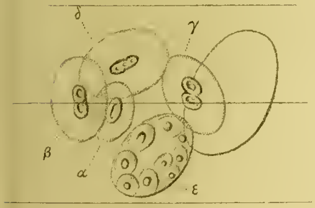
48
Turtle.
Acetic Acid.



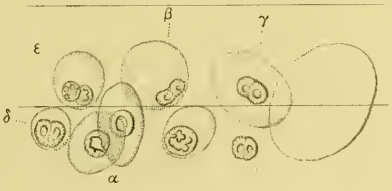
49
Turtle.
Acetic Acid.



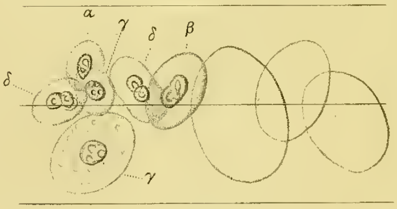
47
Chick in ovo.
166 Hours. Acetic Acid.



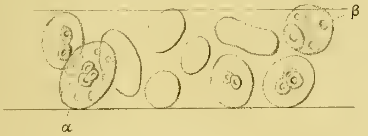
50
Frog.
Acetic Acid.



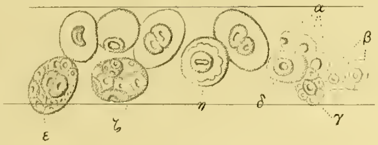
51
Thornback.
Acetic Acid.



52
Skate.
Acetic Acid.



53
Cod.
Acetic Acid.



54
Cod.
Acetic Acid.

All the Objects are magnified 600 Diameters.

(The horizontal Lines are described at the foot of Plate XVII.)

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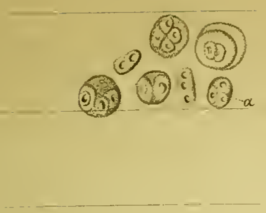
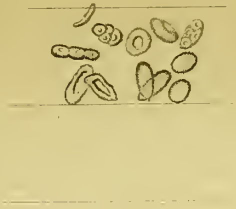
J. Basire sculp.

Corpuscles of the Blood.



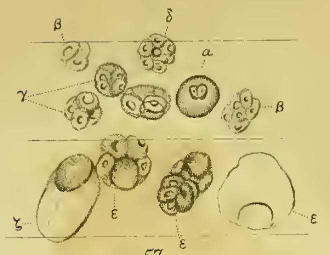
55

Frog.
Acetic Acid.



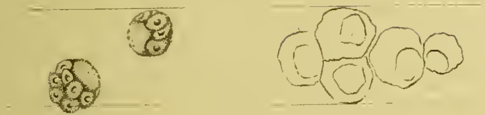
56

Frog.



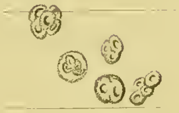
57

Oyster.

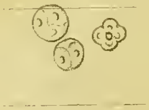


58

Turtle.
Acetic Acid.

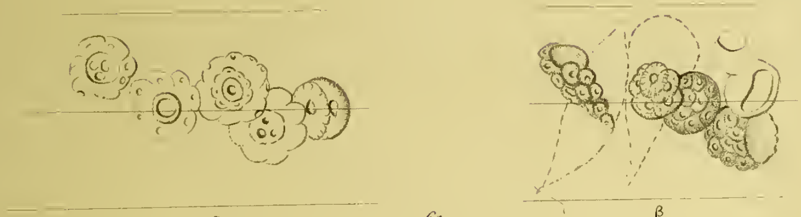


59



60

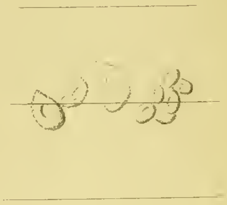
Objects from the Brain, in
the Fœtus of the Ox.
Acetic Acid.



α
Dilute Spirit.

61
Lobster.

β
Acetic Acid.

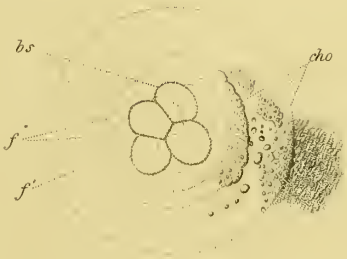


62
Leech.

All the Objects are magnified 600 Diameters.

(The horizontal Lines are described at the foot of Plate XVII.)

Embryology. (see p. 193.)

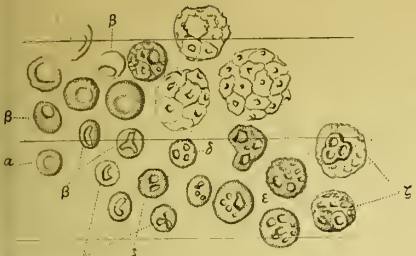


254

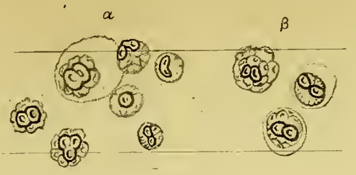
bs The Germ.
f "Zona pellucida".
f' Fluid imbibed by the Chorion.
cho Objects giving origin to the Chorion.

Ad Nat. del. Martin Barry.
J. Basire sculp.

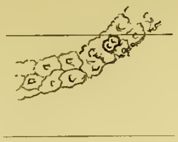
Corpuscles of the Blood.



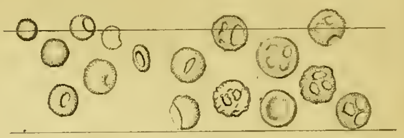
63



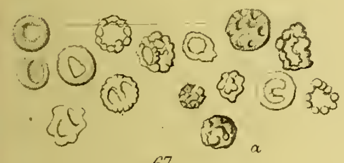
64



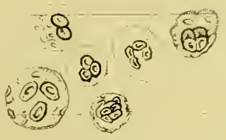
65



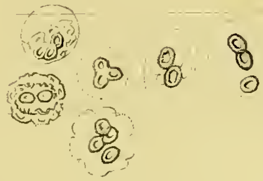
66



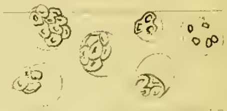
67



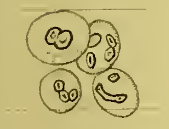
68



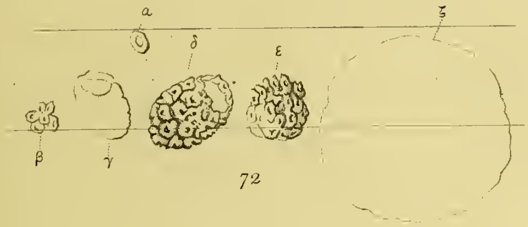
69



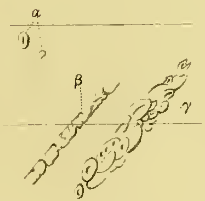
70



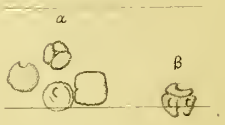
71



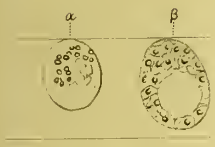
72



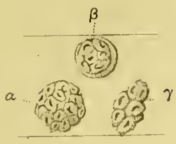
73



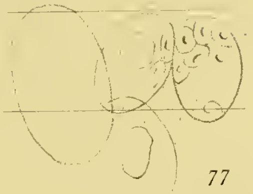
74
Tadpole 6‴



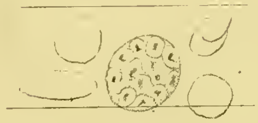
75
Tadpole 6‴



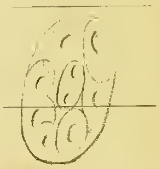
76
Tadpole 6‴



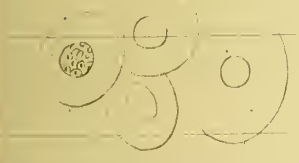
77
Newt.



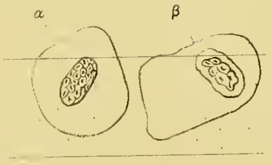
78
Newt.



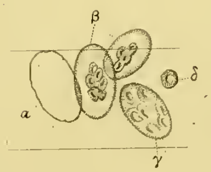
79
Newt.
Acetic Acid.



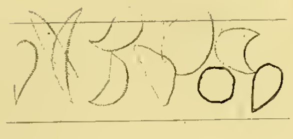
80
Newt.
Nitrate of Silver.



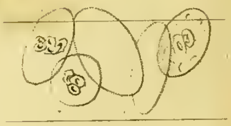
81
Newt.
Corrosive Sublimate.



82
Green Lizard.



83
Fœtal Duck.



84
Fœtal Duck.

All the Objects are magnified 600 Diameters.—(The horizontal Lines are described at the foot of Plate XVII.)

Figs. 63 to 67. Nucleus of the Blood-corpuscle passing into the Pus-globule.

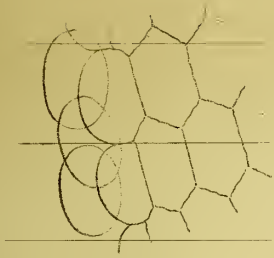
68 to 73. Globules, Cells, &c. of Mucus—derived from Corpuscles having the same appearance as Corpuscles of the Blood.

74 to 84. Blood-corpuscles, and Objects found along with them.

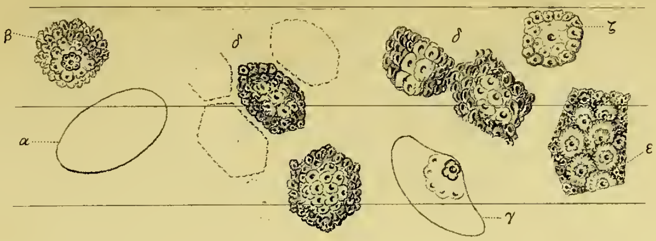
Ad Nat. del. Martin Barry.
J. Basire sculp.

Phil. Trans. MDCCCXLI. *Plate* XXI. *p.* 268.

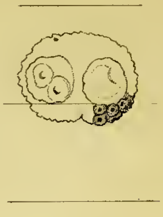
Corpuscles of the Blood.



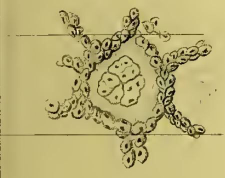
85



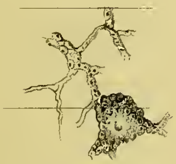
86



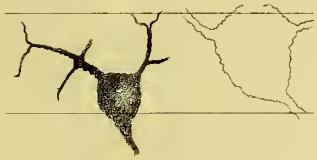
87



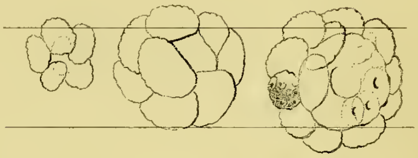
89



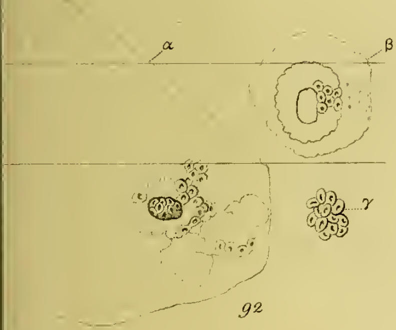
90



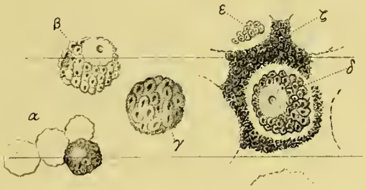
91



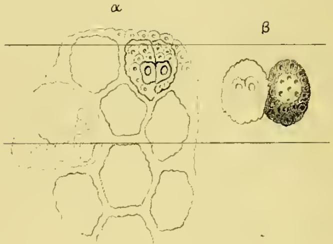
88



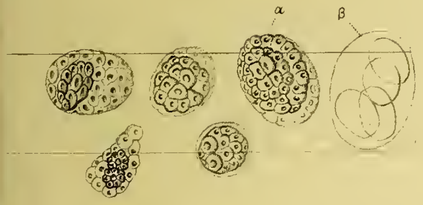
92



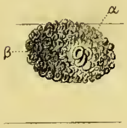
93



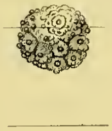
94



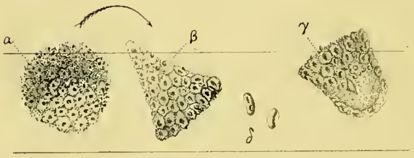
95



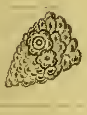
96



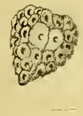
97



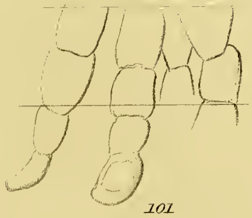
98



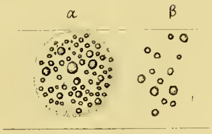
99



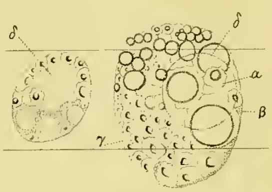
100



101



102



103

All the Objects are magnified 600 Diameters. — (The horizontal Lines are described at the foot of Plate XVII.)

Fig^s. 85 to 94. Epithelium-tables, cells, and cylinders — and Pigmentum nigrum { *Derived from Corpuscles having the same appearance as Corpuscles of the Blood.*

95. Blood-corpuscles, altered.

96 to 100. Epithelium cylinders
101. Ciliary Processes
102, 103. Miscellaneous Objects } .... *Ditto.*

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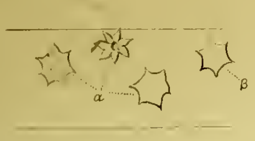
Corpuscles of the Blood.



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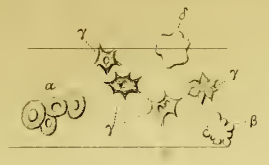

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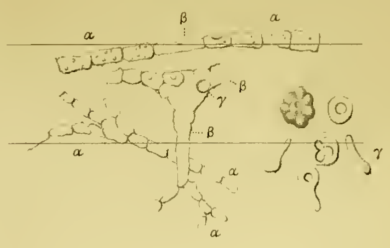

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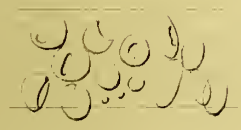

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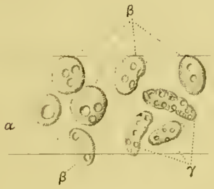

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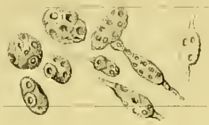

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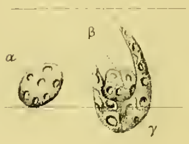

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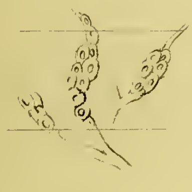

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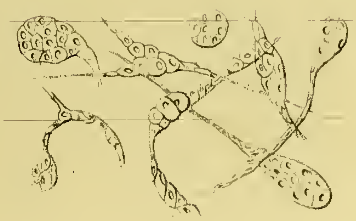

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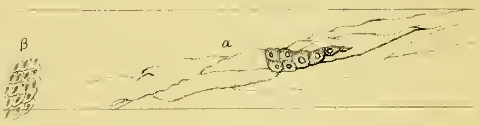

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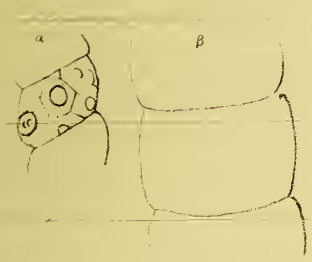

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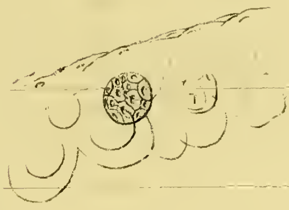

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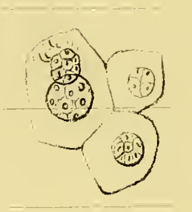

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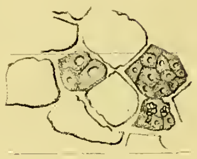

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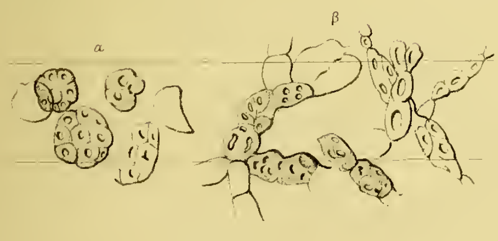

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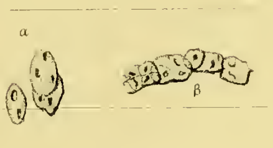


122

All the Objects are magnified 600 Diameters. — (The horizontal Lines are described at the foot of Plate XVII.)

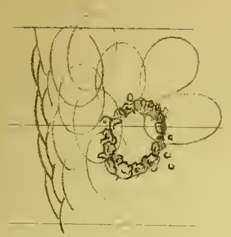
Figs 104 to 106.	Ciliated Nuclei of Blood-corpuscles, Young Blood-corpuscles, &c.
107.	Elements of Capillaries, &c.
108 to 116.	Elements of Cellular Tissue.
116½ to 122.	Elements of Cartilage.

} Derived from Corpuscles having the same appearance as Corpuscles of the Blood.

Ad Nat. del. Martin Barry

J. Basire sculp.

Corpuscles of the Blood.



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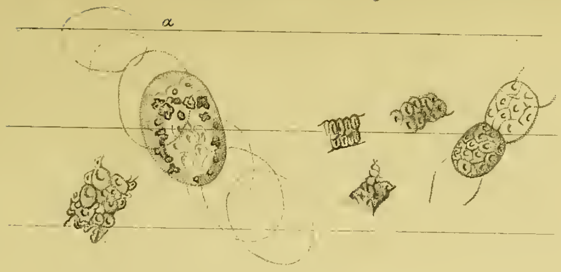

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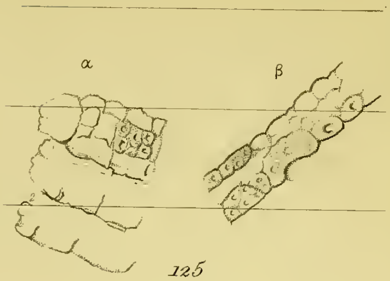

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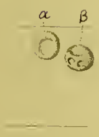

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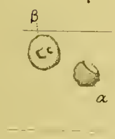

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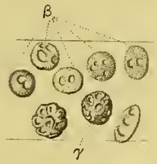

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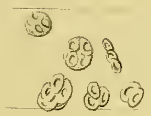

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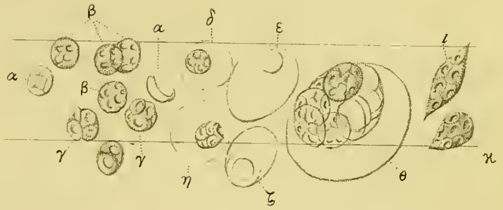

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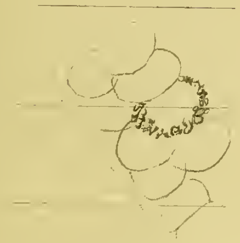

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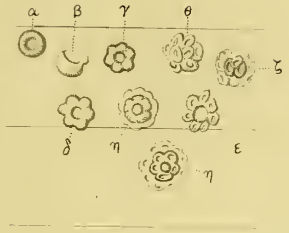

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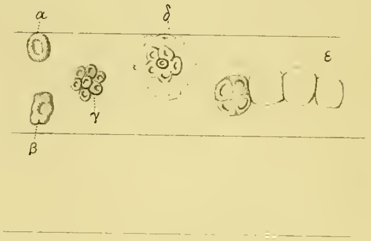

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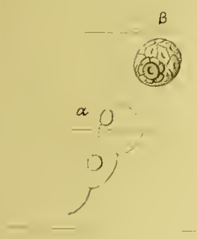

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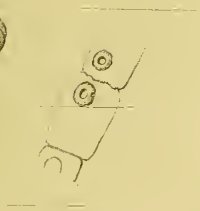

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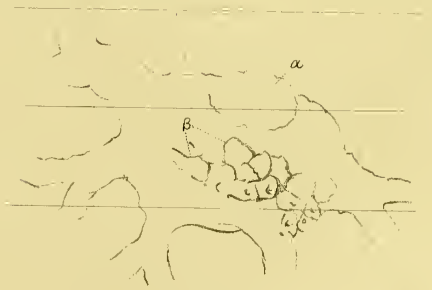

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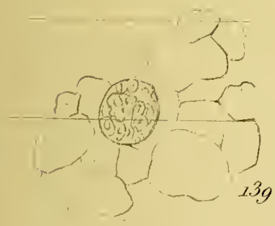

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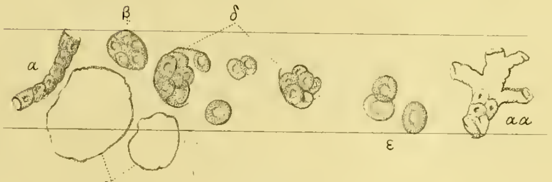


141

All the Objects are magnified 600 Diameters. (The horizontal Lines are described at the foot of Plate XVII.)

Fig.s 123 to 125. Elements of the Optic Nerve.

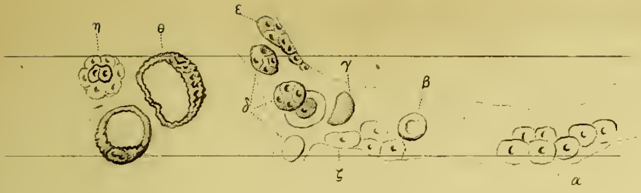
126 to 131 .... Retina.
132 .... Spinal Chord.
133, 134 .... Brain.
135 to 137. .... Muscle.
138 to 141. .... Crystalline Lens.

Derived from Corpuscles having the same appearance as Corpuscles of the Blood.

Ad Nat. del. Martin Barry.

J. Basire sculp.

Corpuscles of the Blood.



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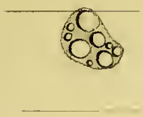

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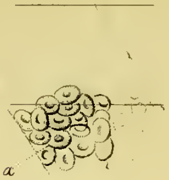

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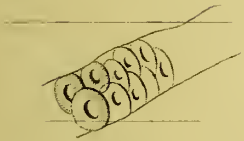

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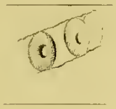

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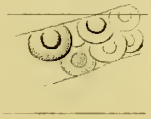

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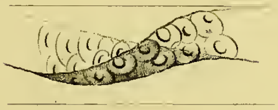

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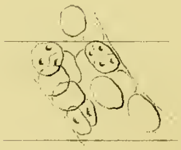

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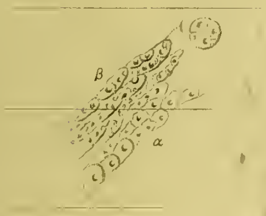

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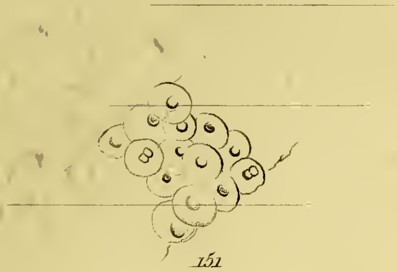

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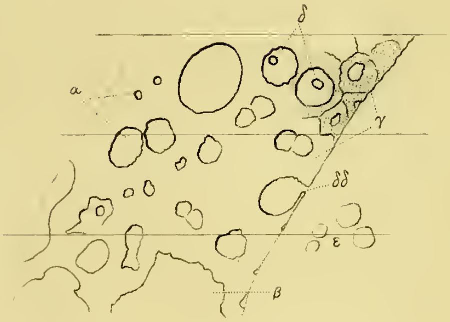

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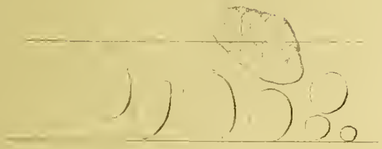

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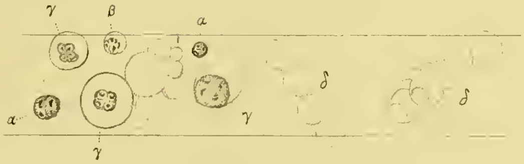

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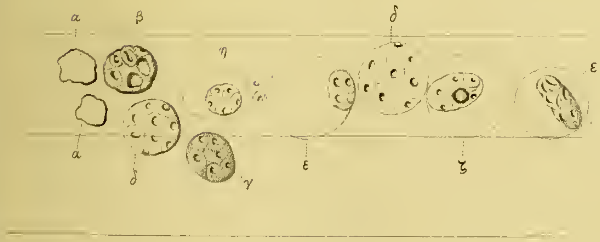

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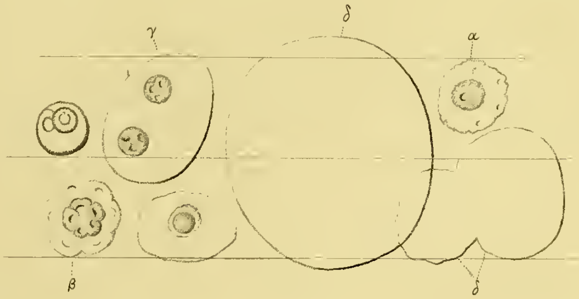

156

All the Objects are magnified 600 Diameters.—(The horizontal Lines are described at the foot of Plate XVII.)

Elements of the Crystalline Lens, derived from Corpuscles having the same appearance as Corpuscles of the Blood.

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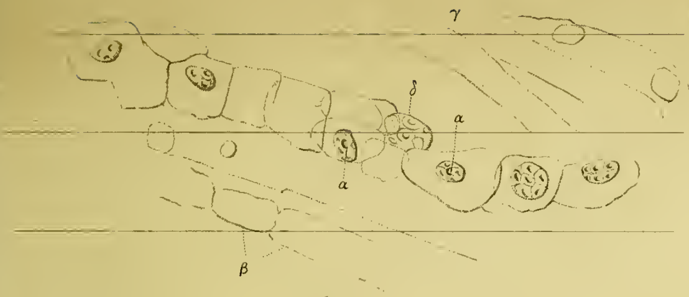
J. Basire sculp.

Corpuscles of the Blood.



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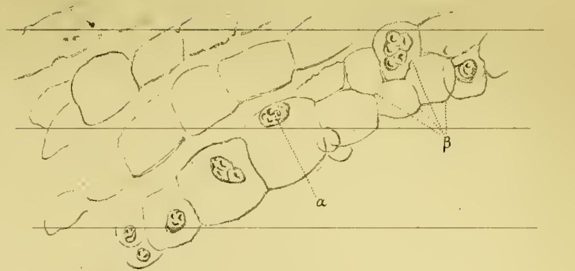

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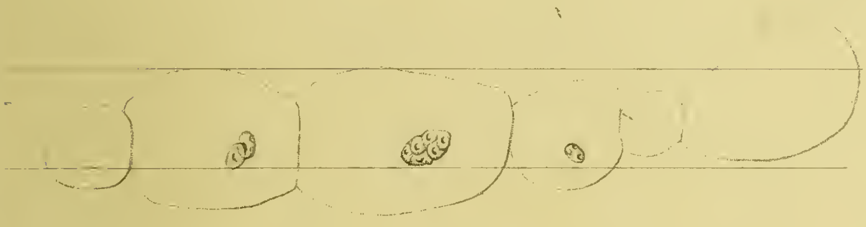

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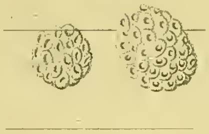

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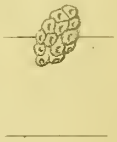

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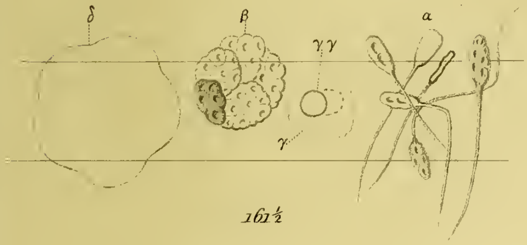

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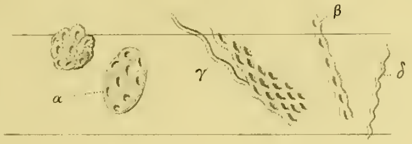

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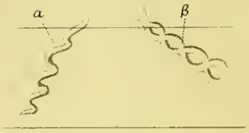

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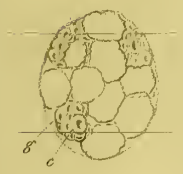

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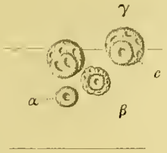

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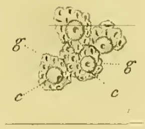

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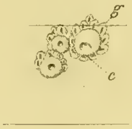

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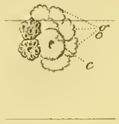

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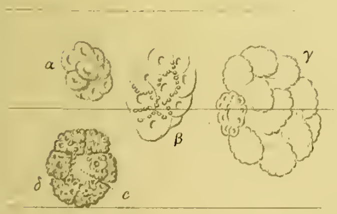

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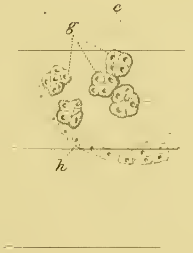

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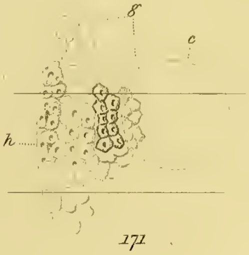

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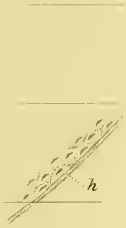

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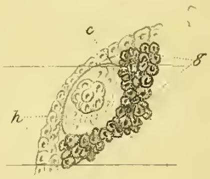

173

All the Objects are magnified 600 Diameters. (The horizontal Lines are described at the foot of Plate XVII.*)*

Fig^{s} *157 to 159. Elements of the Crystalline Lens*
160 to 163. Elements of the Spermatozoa
164 to 173. Elements of the Ovum
Derived from Corpuscles having the same appearance as Corpuscles of the Blood.

Ad Nat. del. Martin Barry.

J. Basire sculp.